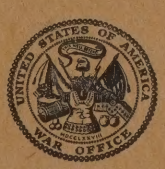
TM 11-2441

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

TIME SIGNAL SET ML-390/U



DEPARTMENT OF THE ARMY • MARCH 1956

AGO 5879A—Mar

TECHNICAL MANUAL
No. 11–2441

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *23 March 1956*

TIME SIGNAL SET ML–390/U

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CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual contains instructions for the installation, operation, maintenance, and repair of Time Signal Set ML–390/U. A discussion of the theory of operation is also included.

b. Throughout this manual, the major component (fig. 1) of Time Signal Set ML–390/U will be referred to as signal set.

c. Forward comments on this publication directly to: Commanding Officer, The Signal Corps Publication Agency, Fort Monmouth, New Jersey.

2. Forms and Records

a. Unsatisfactory Equipment Reports. DA Form 468 (Unsatisfactory Equipment Report) will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in AR 700–38.

b. Damaged or Improper Shipment. DD Form 6 (Report of Damaged or Improper Shipment) will be filled out and forwarded as prescribed in AR 700–58.

Section II. DESCRIPTION AND DATA

3. Purpose

a. Time Signal Set ML–390/U (fig. 1) provides the observer at a plotting or theodolite station with a time interval signal. This time interval signal is used in conjunction with reference signals received during rawinsonde flights made to obtain wind data. The red hands in the timers can be stopped immediately upon the receipt of such reference signals to allow the observer to record the timer readings. Meanwhile the timing mechanism continues operating to time the flight.

b. The equipment generates a periodic 1,000-cycle tone at 30- or 60-second intervals for azimuth and elevation readings. The timing mechansim (*a* above) is synchronized with the 1,000-cycle tone circuit.

4. Use

The ML–390/U is an accessory unit used with Radio Set SCR–658 at a plotting or theodolite station. The periodic 1,000-cycle tone signal is transmitted to Radio Set SCR–658 (TM 11–1158A, Radio Set SCR–658) over a communication line connected to the signal set. This 1,000-cycle tone signal can be heard on headsets plugged directly into the PHONES jacks on the signal set.

5. Table of Components (fig. 1)

Component	Quantity	Dimensions (in.)			Volume (cu ft)	Weight (lb)
		Height	Width	Depth		
Signal set	1	19 9/16	13 5/8	7 3/4	1.2	35.1
Foot switch	1	5 1/4	4	3	.06	2
Power cable	1			10 ft	.03	1/2

Note. This list is for general information only. See appropriate supply publications for information pertaining to the requisitioning of spare parts.

6. Description (fig. 1)

The signal set is mounted in a carrying case with a detachable cover. A section of the carrying case is used to store the power cable and the foot switch assembly. The front panel and chassis assembly mounts the two timers, circuits, controls, and binding posts. The foot switch assembly consists of a foot switch, a 10-foot cable and a plug connector. The 10-foot power cable is fitted with plug connectors on each end.

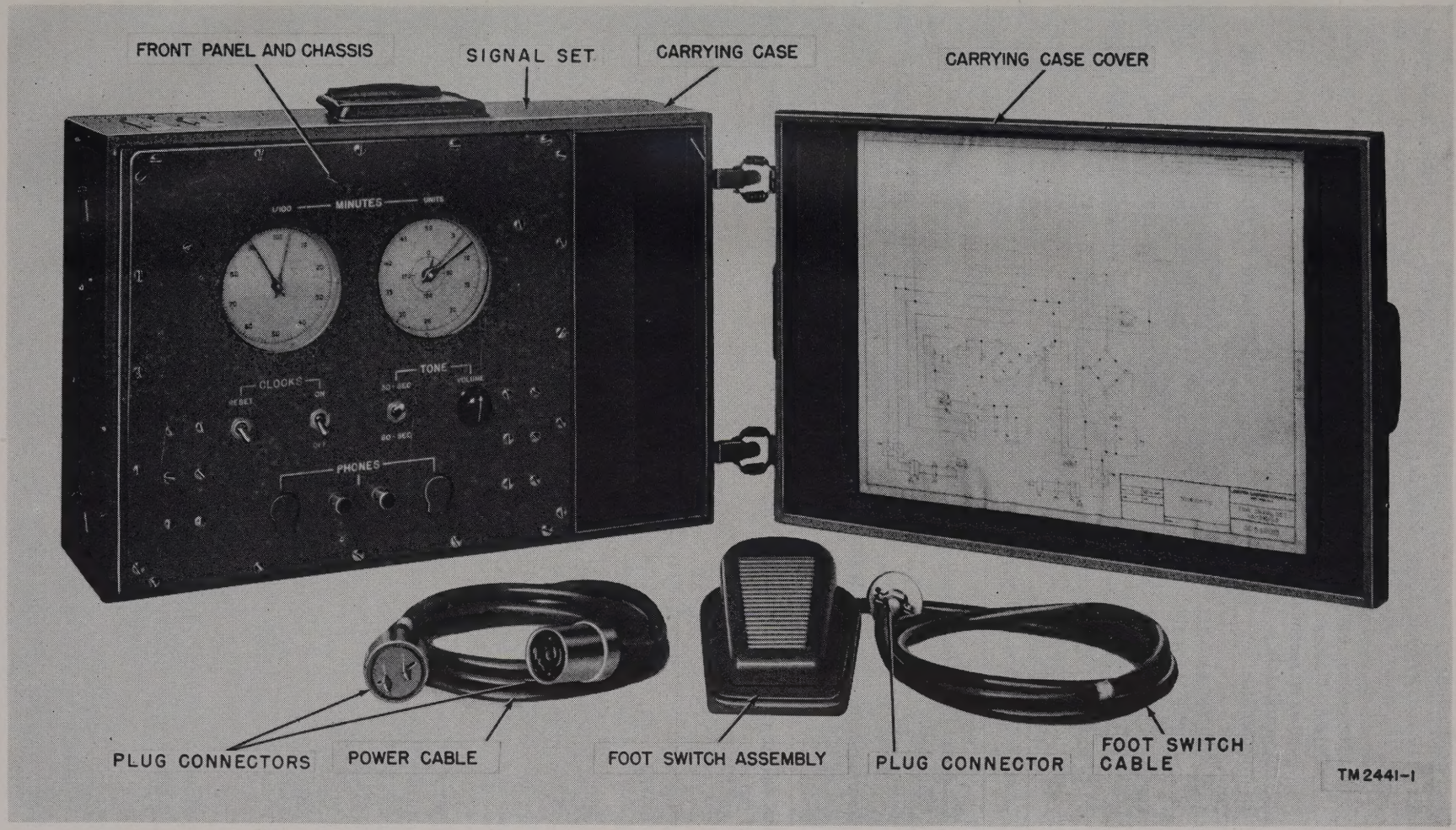

Figure 1. Time Signal Set ML–390/U.

7. Technical Characteristics

Power requirements—115-volt, 60-cycle, single-phase ac; 115 watts.

Output signal:

- Frequency—1,000 cycles, ±20%.
- Type—Pulsed, 7-second duration every 30 or 60 seconds.
- Voltage—Approximately 1 volt into 600-ohm line.

Temperature range:

- Operating—−40° F. to +125° F.
- Storage—−80° F. to +160° F.

Timers:

- Left hand (1/100). Hands make complete revolution in 1 minute. Each division represents 1/100 minute.
- Right hand (UNITS). Large hands make complete revolution in 50 minutes; each division on outer scale represents 1 minute. Small hand makes complete revolution in 200 minutes; each division on inner scale represents 50 minutes.

8. Additional Equipment Required

The following equipments are not supplied as part of Time Signal Set ML–390/U but are required for transmission of its periodic 1,000-cycle timing tone to a theodolite and plotting station:

Quantity	Name	Type or characteristic
1	Head and Chest Set HS–25, HS–25A, or HS–25B.	Sound powered transmitter-receiver.
1	Plug PL-57	Telephone plug to fit PHONES jacks on signal set. Used with HS–25, HS–25A, or HS–25B.
¼-mile length	Communition line wire (WD–1/TT).	¼ mile of wire for interconnecting communication line.
1	Reel RL–39 or RL–39–A.	Wire reel for communication line.

Note. This list is for general information only. See appropriate publications for information pertaining to requisitioning of parts.

CHAPTER 2
INSTALLATION

9. Uncrating and Unpacking New Equipment

Note. For instructions for used or reconditioned equipment, refer to paragraph 11.

a. General. The components of the ML–390/U may be received packed for export or domestic shipment.

Caution: Be careful when uncrating, unpacking, and handling the equipment; it is easily damaged.

b. Domestic Shipment. When packed for domestic shipment, the ML–390/U is cushioned on all surfaces with felt pads and corrugated fillers to absorb the shock of impact normally encountered in handling and transit. The unit then is placed inside an inner corrugated carton with a desiccant package containing silica gel. All closures of the inner corrugated carton are sealed with gummed tape. The boxed ML–390/U then is placed within a moisture-vapor-proof barrier. The sealed equipment then is placed within an outer corrugated carton. All closures of the outer corrugated carton are sealed with gummed tape.

c. Export Shipment. When packed for export shipment, the ML–390/U is packaged as for domestic shipment (*b* above), and then placed within a moistureproof barrier. Th unit then is placed in a wooden packing case. The wooden cover is nailed on and the wooden packing case is bound with metal straps. The dimensions of the wooden packing case for the ML–390/U are approximately 9½ inches high, 15½ inches wide, and 23 inches deep. The volume is approximately 2 cubic feet and the weight approximately 67 pounds.

d. Uncrating and Unpacking Export-Packed Equipment (fig. 2).

(1) Place the wooden packing case as near the operating position as convenient. Choose a location where the equipment will not be exposed to dust, dirt, or excessive moisture.

(2) Cut the metal straps with a suitable cutting device or twist them with pliers until the straps break.

(3) Remove the nails from the wooden cover and one side of the wooden packing case; use a nail puller. Avoid thrusting crowbars or other tools into the interior of any shipping container. Damage to the contents may result.

(4) Lift out the packaged equipment.

(5) Slit the moistureproof barrier at the seams and remove it from the package.

(6) Slit the seam of the outer corrugated carton and lift out the moisture-vapor-proof package.

(7) Slit the seam of the moisture-vapor-proof barrier and lift out the inner corrugated carton.

(8) Slit the seal of the inner corrugated carton, open the flaps, and lift the ML–390/U out of the carton.

(9) Release the spring catches and lift off the carrying case cover. Remove the foot switch assembly and the power cable; place them in a convenient place for checking.

e. Unpacking Domestic-Packed Equipment. When packed for domestic shipment, the ML–390/U is packed as for export shipment except that the wooden packing case and moisture-proof barrier are not used. To unpack equipment packed for domestic shipment, proceed as instructed in *d*(6) through (9) above.

10. Checking

a. Check the contents with the packing slip to see whether any components of the equipment are missing.

b. Place the equipment on a bench and examine it for broken or damaged parts.

c. Place the foot switch assembly and the

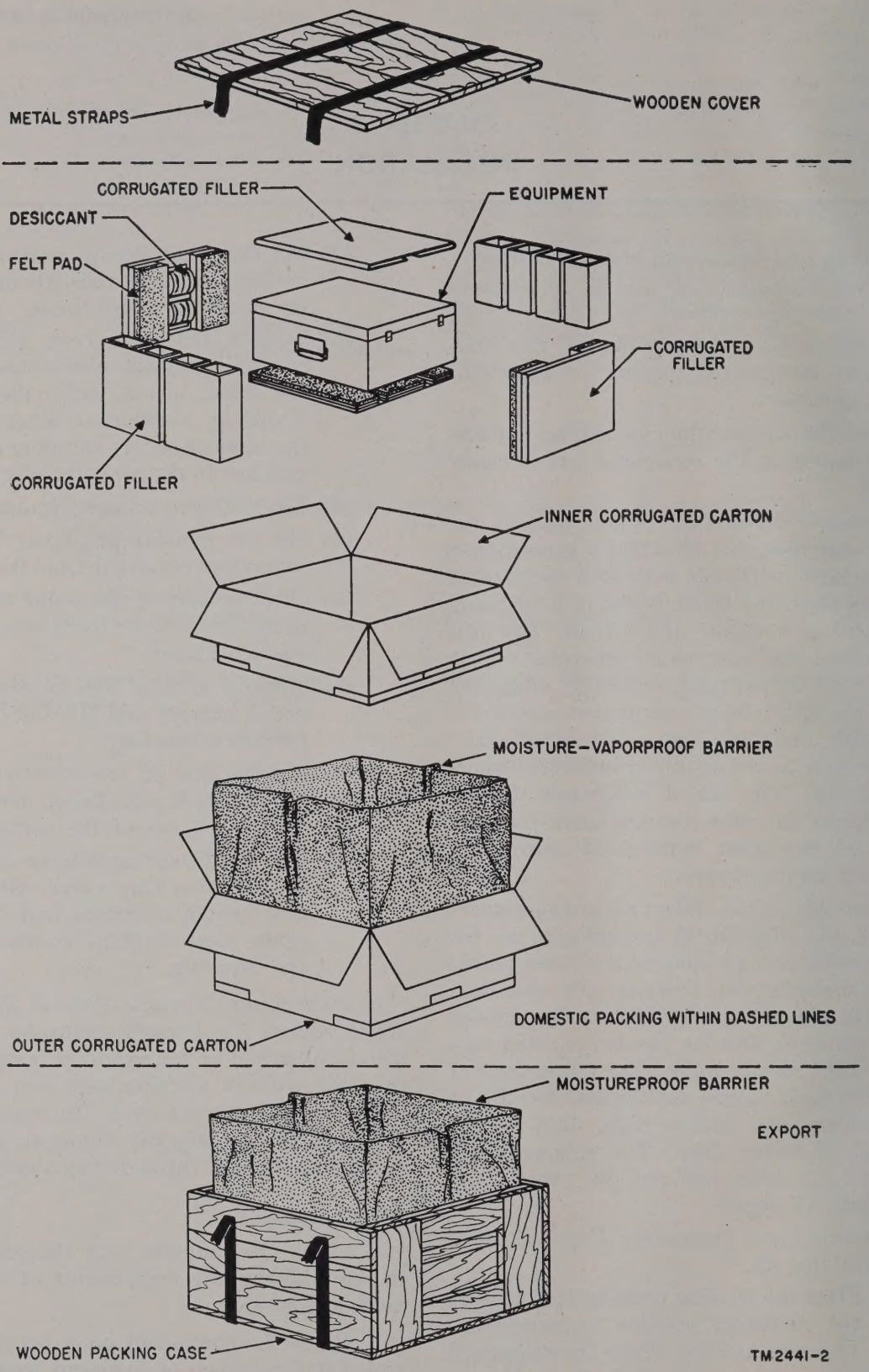

Figure 2. Typical packaging diagram.

power cable back in the carrying case after checking.

Note. If the equipment is damaged or has broken parts, turn it in for repair.

11. Service Upon Receipt of Used or Reconditioned Equipment

a. Used or reconditioned equipment is packed in the same manner as new equipment. Unpack used or reconditioned equipment as described in paragraph 9*d* or *e* for new equipment.

b. Check the used or reconditioned equipment for tags or other indications of changes in the wiring of the equipment. If any changes have been made in wiring, note the change on the schematic and wiring diagrams in this technical manual, and on the inside of the carrying case cover.

12. Installation

Install the equipment as follows:

a. Hand-carry the ML–390/U to a convenient location within 12 feet of its associated plotting board.

b. Place the ML–390/U in position with the carrying handle on top.

c. Unlatch the spring catches and remove the carrying case cover.

d. Remove the power cable and the foot switch assembly from the right-hand compartment of the carrying case.

e. Place the foot switch assembly near the plotting board observer.

13. Precautions During Installation

a. Be sure that high-tension, telephone, or other wires not related to the ML–390/U do not come in contact with the signal set communication line.

b. Be sure that the power source is 110- to 120-volt, 60-cycle alternating current (ac).

14. Connections (fig. 3)

a. Move the CLOCKS ON–OFF switch (fig. 4) to the OFF position.

b. Connect the power cable plug connector to the recessed receptacle connector on the carrying case divider panel. Connect the plug connector on the power cable into a 110- to 120-volt, 60-cycle ac power source.

c. Insert the plug connector on the foot switch cable into the receptacle connector on the carrying case divider panel.

d. Connect the communication wire line to the PHONES binding posts on the signal set. Connect the other end of the communications line wire to the lower junction box on the vertical column of Support FT–478 (part of Radio Set SCR–658, TM 11–1158A).

e. Plug the telephone headset (HS–25, HS–25–A, or HS–25–B) into either PHONES jack on the signal set.

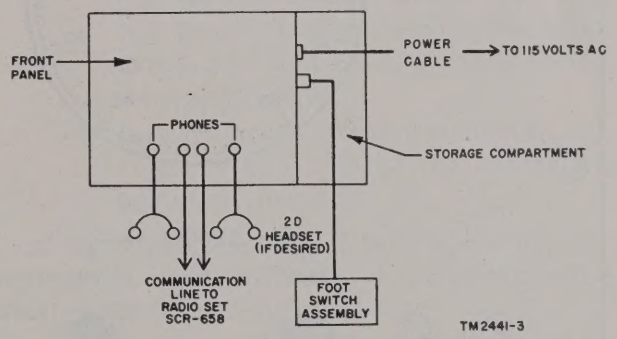

Figure 3. Interconnection diagram.

CHAPTER 3
OPERATION

Section I. CONTROLS

15. General

Haphazard operation or improper setting of the controls on this equipment will not produce the precise timing signals required. For this reason, it is important to know the operation and function of each control. The operation of the ML–390/U is discussed in paragraphs 17 through 20.

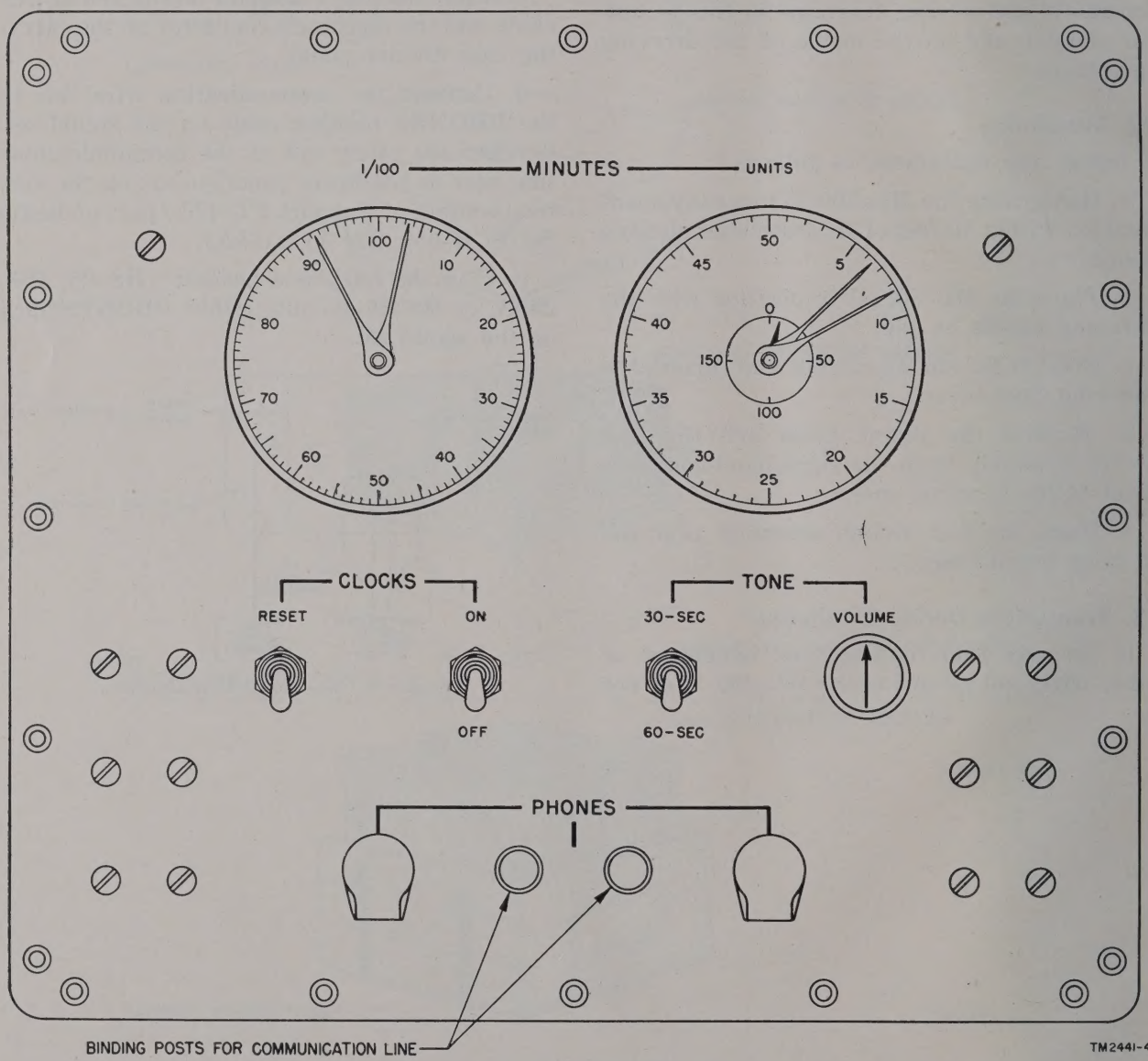

Figure 4. Signal set front panel, controls, binding posts, and timers.

16. Controls and Connections
(figs. 4 and 6)

The following charts list the controls and connections of the time signal set and give the function of each item.

a. Controls.

Control	Function
CLOCKS ON-OFF switch	Connects the 115-volt, 60-cycle ac input to the two timers and to the 1,000-cycle tone circuit.
RESET switch	Energizes the reset mechanism that returns all hands on both timers to the start position.
30-SEC—60-SEC switch	Selects 1,000-cycle tone interval.
VOLUME control	Controls the volume of the 1,000-cycle tone.
Foot switch	Stops and resets the red hand on each of the two timers.

b. Connections.

Connection	Function
PHONES jacks	Connections for telephone headsets.
PHONES binding posts	Connections for communications line (Radio Set SCR–658).
Power receptacle connector	Connection for power cable.
Foot switch receptacle connector	Connection for foot switch cable.

Section II. OPERATION UNDER USUAL CONDITIONS

17. Preliminary Checks and Adjustments
(fig. 4)

Before operating the equipment, perform each of the operations described below in the order in which they are listed.

a. Application of Power. Connect the power cable to a 110- to 120-volt, 60-cycle power source. Application of power warms up two internal resistors which dehumidify the signal set.

Note. The equipment must be moisture-free to operate properly. Allow the set to warm up for 15 minutes before proceeding to the next operation.

b. Foot Switch Operational Check. Check the operation of the foot switch in the following manner:

(1) Move the CLOCKS ON–OFF switch to the ON position.

(2) Observe the movement of the black and red hands on both timers. One of the two following conditions should exist:

(*a*) Both the red and the black hands are rotating.

(*b*) Only the black hands are rotating.

Note. The small hand on the UNITS timer rotates very slowly. It may be necessary to wait 10 minutes before any change in its position can be noticed.

(3) Press the foot switch. If the condition outlined in (2) (*a*) above existed, pressing the foot switch should stop the red hands. If the condition outlined in (2) (*b*) above existed, pressing the foot switch should cause the red hands to snap behind the black hands, and both sets of hands should rotate together.

(4) Repeat the operation described in (3) above to be sure that the timers are operating properly.

c. Resetting Timers. Before operating the equipment, reset the hands of the clocks to the start position as follows:

(1) Move the CLOCKS ON–OFF switch to the OFF position.

(2) Press down and release the RESET switch. This should return the hands to the start position. There is a *dead spot* position in each timer, from which the hands may not return to the start position when the RESET switch is operated. These positions are the 50 position on the 1/100 timer and the 25 position on the UNITS timer. If this condition exists, first operate the RESET switch several more times. If the hands still do not reset, move the

CLOCKS ON–OFF switch to the ON position and allow the hands on the timers to pass the dead spots. Move the CLOCKS ON–OFF switch to the OFF position; then press down and release the RESET switch. Repeat this procedure, if required, until all hands are at the start position.

d. Tone Adjustment.

(1) Move the 30–SEC—60–SEC switch to the 30–SEC position. A 1,000-cycle tone should be heard every 30 seconds in each connected headset. Each tone should last about 7 seconds and should start and stop abruptly. Note that both the pitch and volume of the tone remain constant during the entire duration of the signal.

(2) Turn the VOLUME control until a comfortable sound level is established at all listening stations.

(3) Set the 30–SEC—60–SEC switch to the 60–SEC position. The time lapse between tones now should be 60 seconds. All other characteristics should remain the same as those described in (1) above.

18. Reading the Timers

Before operating the ML–390/U, it is essential that the operator be thoroughly familiar with the procedure for reading the timers. Speed in recording the data obtained from the timers is essential. How the timers operate and how to obtain timer readings are explained in *a* and *b* below, also included are several examples. Figure 5 illustrates some typical indications that can be obtained from the timers. Note that the readings obtained from both timers are cumulative.

a. Scale Calibration. The UNITS timer has two concentric scales. The outer scale is the reference for the large black and large red hands; the inner scale is the reference for the small black hand only.

(1) The two large hands of the UNITS timer make 1 complete revolution in 50 minutes. This scale is graduated uniformly into 50 divisions; each division, therefore, represents 1 minute. When reading this (or any other) scale, record the number of the scale division just *passed* by the hand.

(2) The small black-hand position is indicated on the inner scale. This hand makes 1 complete revolution in 200 minutes. The four equally spaced divisions are 50 minutes apart and the reading for each is marked alongside the calibration line. The 0 (start position corresponds also to 200 minutes of elapsed time.

(3) The 1/100 timer has one scale; this scale is used for reading the position of both the red and the black hands on this timer. The two hands of the 1/100 timer make 1 complete revolution every minute. This scale is graduated uniformly into 100 divisions; each scale division therefore represents 1/100 minute.

b. Reading Timers. Two separate readings can be obtained with the timers. One is called the *delayed total time* and is the reading used most often during the operation of the equipment. The other is called the *instantaneous total elapsed time.*

(1) *Delayed total time readings.*

(*a*) *Usual reading.* The delayed total time reading determines the time elapsed from the moment the foot switch is pressed to start the red hands until it is again pressed to stop them. Obtain this reading by summing up, in the order listed, the number of scale positions just passed by the following hands:

1. The small black hand on the UNITS timer.

2. The red hand on the UNITS timer.

3. The red hand on the 1/100 timer.

(*b*) *Typical examples.*

1. In A, figure 5, the delayed total time is:

200-minute dial (UNITS timer, small black hand)	000.0
50-minute dial (UNITS timer, red hand)	18.0
1-minute dial (1/100 timer, red hand)	.81
Delayed total time =	18.81 min.

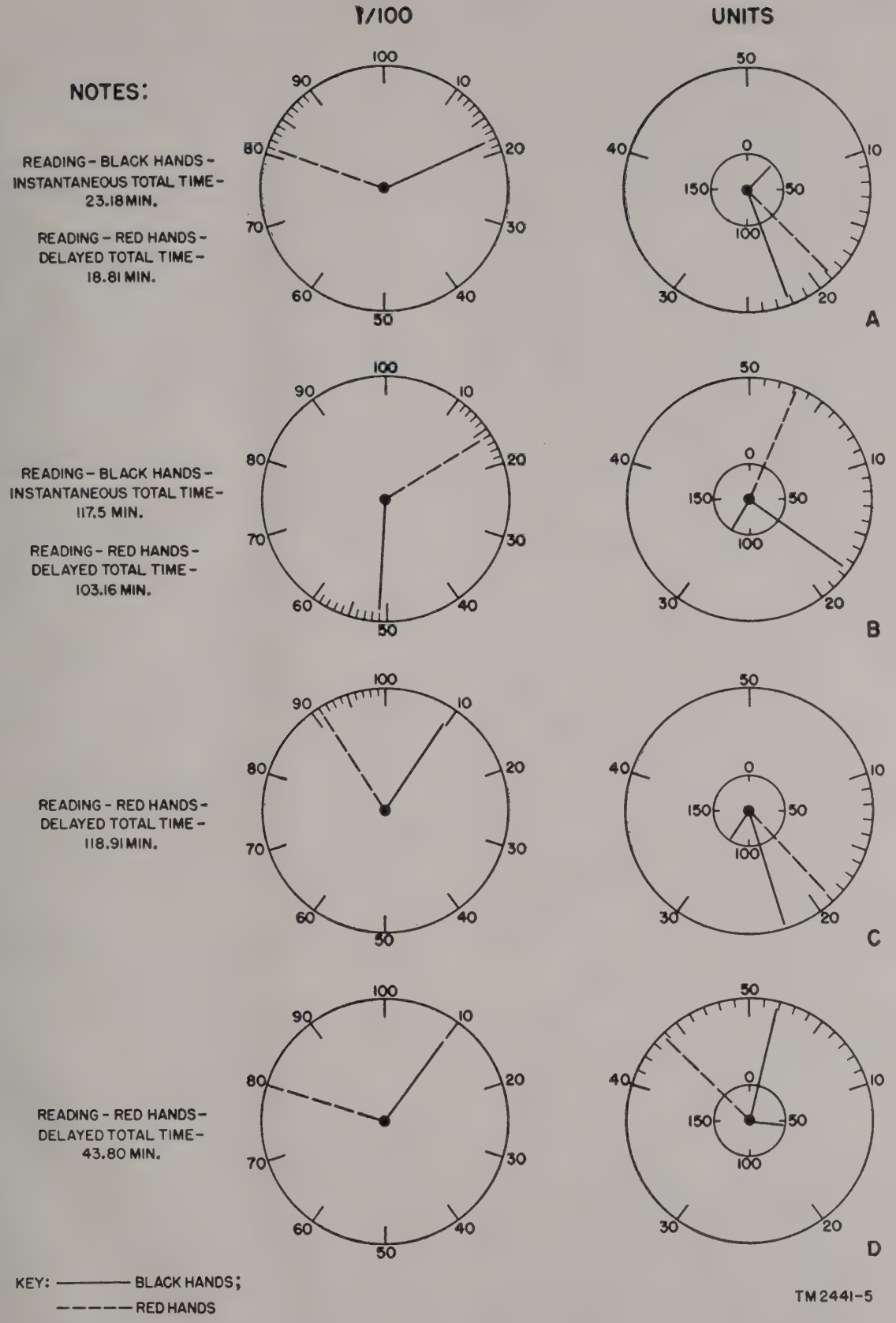
1/100
UNITS
NOTES:
READING - BLACK HANDS - INSTANTANEOUS TOTAL TIME - 23.18 MIN.
READING - RED HANDS - DELAYED TOTAL TIME - 18.81 MIN.
A
READING - BLACK HANDS - INSTANTANEOUS TOTAL TIME - 117.5 MIN.
READING - RED HANDS - DELAYED TOTAL TIME - 103.16 MIN.
B
READING - RED HANDS - DELAYED TOTAL TIME - 118.91 MIN.
C
READING - RED HANDS - DELAYED TOTAL TIME - 43.80 MIN.
D
KEY: ——— BLACK HANDS;
– – – – – RED HANDS
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Figure 5. Typical indications on timers.

2. In B, figure 5, the delayed total time is:

200-minute dial (UNITS timer, small black hand)	100.0
50-minute dial (UNITS time, red hand)	3.0
1-minute dial (1/100 timer, red hand)	.16

Delayed total time = 103.16 min.

(*c*) *Special cases.* Two types of situations may be encountered in which an erroneous reading could be made unless the observer is specially careful in reading the timers.

1. If the red hand of the UNITS timer seems to be directly over one of the scale graduations, it may be difficult to determine whether the number of that graduation mark or the number of the one immediately preceding it should be recorded. To resolve the difficulty, refer to the position of the red hand on the 1/100 timer. C, figure 5, illustrates a typical condition. The reading of the red hand of the UNITS timer may be 18 or possibly 19. By referring to the red hand on the 1/100 timer, it can be seen that this hand has not yet completed its revolution. Therefore, the UNITS red hand reading is 18. The delayed total time reading obtained from the positions of the hands shown in C, figure 5, is as follows:

200-minute dial (UNITS timer, small black hand)	10.0
50-minute dial (UNITS timer, red hand)	18.0
1-minute dial (1/100 timer, red hand)	.9

Delayed total time = 118.9 min.

2. If the small black hand of the UNITS timer is directly over(or has just passd one of its graduation marks), it may be difficult to determine whether the number of that graduation mark or the number of the one immediately preceding should be recorded. (Note also that the black hand continues to rotate after the red hand stops.) To establish the correct graduation mark, refer to the red hand of the same (UNITS) timer. D, figure 5, illustrates a typical condition. The position of the small black hand of the UNITS timer indicates that more than 50 minutes have elapsed. However, since the black hand is so close to the graduation line, it is possible that the red hand was stopped before this graduation line. Note that the red hand on the UNITS timer has not yet completed its travel (reads less than 50). This indicates that the reading of the small black hand was less than 50. Therefore, the delayed total time reading obtained from the position of the timer hands shown in D, figure 5, is as follows:

200-minute dial (UNITS timer, small black hand)	000.0
50-minute dial (UNITS timer, red hand)	43.0
1-minute dial (1/100 timer, red hand)	.80

Delayed total time = 43.80 min.

(2) *Instantaneous total elapsed time readings.*

(*a*) *Usual reading.* The instantaneous total elapsed time is a reading of one or more *delayed total times* that may be taken at any period during a complete operation. The instantaneous total elapsed time is determined by the positions of the black hands on both timers and is obtained by summing up, in the order listed, the number of the scaled position just passed by the following hands:

1. The small black hand on the UNITS timer.
2. The large black hand on the UNITS timer.
3. The black hand on the 1/100 timer.

(*b*) *Typical examples.*

1. In A, figure 5, the instantaneous total elapsed time is:

200-minute dial (UNITS timer, small black hand)	000.0
50-minute dial (UNITS timer, large black hand)	22.0
1-minute dial (1/100 timer, black hand)	.18
Instantaneous total elapsed time	= 22.18 min.

2. In B, figure 5, the instantaneous total elapsed time is:

200-minute dial (UNITS timer, small black hand)	100.0
50-minute dial (UNITS timer, large black hand)	17.0
1-minute dial (1/100 timer, black hand)	.51
Instantaneous total elapsed time	= 117.51 min.

(*c*) *Special cases.* The same special cases described in (1) (*c*) above arise when taking instantaneous total elapsed time readings. Observe the same precautions when the black hands are used for reference.

19. Operation

a. Press the foot switch to start the red hands of both timers rotating (fig. 3).

b. Move the CLOCKS ON–OFF switch to the OFF position.

c. Reset the timer (par. 17*c*).

d. Move the 30-SEC—60-SEC switch to the 30-SEC position unless the theodolite or plotting station asks for the 60-SEC tone interval.

e. Put on the headset being used at the ML–390/U location.

f. Move the CLOCKS ON–OFF switch to the ON position the instant the flight euipment is released.

g. When a time reference is desired for later reading and recording, press the foot switch to stop the red hands on both timers.

h. At the earliest opportunity (and within 50 min.), read and record the delayed total time as described in paragraph 18*b* (1).

i. Again press the foot switch. This will cause the large red hands to snap behind the large black hands and to rotate with them.

j. When one set of observations has been completed, read and record the instantaneous total elapsed time as described in paragraph 18*b* (2).

k. Move the CLOCKS ON–OFF switch to the OFF position.

l. Reset the position of all the timer hands by following the procedure detailed in paragraph 17*c* (2).

20. Stopping Procedure

To stop the equipment, move the CLOCKS ON–OFF switch to the OFF position. Disconnect the power cable.

Section III. OPERATION UNDER UNUSUAL CONDITIONS

21. General

The operation of Time Signal Set ML–390/U may be difficult in regions where extreme cold, heat, humidity, moisture, and similar conditions prevail. While every precaution is taken in the design of the equipment to maintain its technical characteristics over a wide temperature and humidity range (par. 7), adverse conditions may cause equipment failure unless additional precautions are taken. Paragraphs 22 through 24 provide procedures that minimize the effects of these unusual climatic conditions.

22. Operation in Arctic Climates

When the equipment has been stored outdoors, or in an unheated shelter at low temperatures for a prolonged period of time, the equipment should be warmed up slowly to avoid condensation. This is accomplished by transferring the equipment from cold to warmer temperatures in several gradual steps, bearing

in mind that there are extremes in temperature between the floor and ceiling in arctic buildings or shelters. Therefore, before operating the equipment in arctic climates proceed as follows:

a. Transfer the equipment indoors to a heated shelter or building and place it on the floor.

b. Leave the equipment in this position for at least 2 hours.

c. At the end of 2 hours, place the equipment at table top level.

d. Loosen the screws that hold the front panel and chassis to the carrying case (fig. 6). This will permit air to circulate inside the front panel and chassis.

e. Leave the equipment in this position for at least 2 hours.

f. Make sure that the CLOCKS ON–OFF switch (fig. 4) is in the OFF position.

g. Apply power to the dehumidifying resistors by connecting the power cable to the power source (par. 7) and to the power receptacle connector (fig. 6).

h. Permit the equipment to warm up and dry out with the aid of the resistors.

i. Tighten the screws on the front panel.

j. Proceed to operate the equipment as described in paragraphs 18 through 20.

23. Operation in Tropical Climates

When operated in tropical climates, the ML–390/U may be installed in tents, huts, or when necessary, in underground dugouts. When equipment is installed below ground and when it is set up in swampy areas, it is subjected to more acute moisture conditions. Ventilation is usually very poor, and the high relative humidity causes condensation of moisture on the equipment whenever the temperature of the equipment becomes lower than that of the surrounding air. To minimize this condition, leave the power cable connected to its power source at all times, even when the equipment is not in use.

24. Operation in Desert Climates

a. Conditions similar to those encountered in tropical climates often prevail in desert areas. Use the same measures to insure proper operation of the equipment.

b. The main problem which arises with equipment operation in desert areas is the large amount of sand or dust and dirt which enters the moving parts of the equipment, such as the timer mechanism. The ideal preventive precaution is to house the equipment in a dustproof shelter. Such a building is seldom available and would require air conditioning; therefore the next best precaution is to make the building in which the equipment is located as dustproof as possible with available materials.

c. Never tie the power cable or communication line to either the inside or the outside of tents. Desert areas are subject to sudden wind squalls which may jerk the connections loose or break the lines.

d. Keep the equipment as free of dust as possible. Make frequent preventive maintenance checks.

CHAPTER 4
ORGANIZATIONAL MAINTENANCE

Section I. FIRST ECHELON (OPERATOR) MAINTENANCE

25. General

The operator is responsible for daily and weekly preventive maintenance routines (par. 29). The operator is not responsible for the replacement of any part. If major adjustments, necessary repairs, or need for replacements are observed by the operator during inspection, a note will be made of these deficiencies and will be referred by the operator to the unit repairman.

26. Preventive Maintenance Tools and Materials

The following tools and materials are required for preventive maintenance of the ML–390/U at first echelon level.

Item	Used to
Screwdriver TL–385/U	Remove the screws that secure the front panel and chassis to the carrying case.
Sandpaper No. 0000	Remove corrosion from contact points and sand rust spots from carrying case.
Dry Cleaning Solvent (SD)	Clean exterior surfaces of the equipment.
Lint-free cloth	Dry moisture that has accumulated on or in the equipment.
Carbon tetrachloride	Clean deposits from contact points.
Cleaning Compound (Federal stock No. 7930–395–9542)	Clean parts that are not electrical.

27. Preventive Maintenance Services

Preventive maintenance procedures for the inspection, tightening, and cleaning of parts that require routine preventive maintenance are explained in paragraph 29. Make a careful inspection of the ML–390/U daily and weekly as indicated (par. 29). It is absolutely essential to keep the equipment clean at all times.

a. Use No. 0000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth for cleaning. If the dry cloth will not remove the dirt, use one of the following techniques, as applicable:

(1) When cleaning electrical contacts, use a cloth moistened with carbon tetrachloride; when contacts are clean, wipe them dry with a clean, *dry* cloth.

Caution: Repeated contact of carbon tetrachloride with the skin or prolonged breathing of the fumes is dangerous. Be sure adequate ventilation is provided.

(2) When cleaning the surfaces of parts that perform no electrical function, use a cloth moistened with Cleaning Compound; after cleaning, wipe the parts dry with a clean, dry cloth.

Caution: Prolonged breathing of Cleaning Compound fumes is dangerous. Be sure that adequate ventilation is provided. Cleaning Compound is flammable; do not use it near a flame.

(3) When cleaning the outside surfaces of the equipment, use a cloth moistened with solvent SD; after cleaning, wipe dry with a clean, dry cloth.

c. For further information on preventive maintenance techniques, refer to TB SIG 178 (Preventive Maintenance Guide for Radio Communication Equipment).

28. Lubrication

The ML–390/U requires lubrication semiannually. Lubricate the shafts and gears of the timers (S5 and S6) as follows:

a. Remove the 20 panel mounting screws

(fig. 6) and lift out the front panel and chassis assembly (fig. 7) from the carrying case.

b. Place a light protective coating of Oil, Lubricating, Preservative, Special (PL Special) on the shafts and gears of the timers (S5 and S6) (fig. 7). Do not overlubricate; 1 or 2 drops will be sufficient.

c. Wipe off any excess oil. Be sure that no oil gets on the electrical connections of the signal set.

d. Replace the front panel and chassis assembly in the carrying case.

e. Screw in the 20 panel mounting screws and tighten them.

29. Preventive Maintenance Procedures (figs. 1, 6, and 7)

The following chart contains information on preventive maintenance.

Caution: Disconnect the power cable before performing the checks described in items 3 through 11. Upon completion, reconnect the cable and check the equipment for satisfactory operation (par. 19).

Item No.	What to check	When to check	How to check	Precautions
1	Exterior of equipment	D	Clean the exterior of the equipment to remove all grease, dirt, and dust. Check the operation of the spring catches.	
2	Interior of equipment	W	Remove the front panel from its carrying case (par. 28) and clean the interior of the cabinet, the exterior of the chassis, and all parts.	
3	Cables	W	Inspect for cuts, breaks, fraying, deterioration, kinks, and strain.	Be sure that the power cable is disconnected from power source.
4	Switches, connectors, and potentiometer (variable resistor).	W	Inspect switches, connectors, and potentiometer (variable resistor) for dirt, corrosion, loose contacts, and unsatisfactory electrical and mechanical operation.	
5	Timers	W	Inspect the timers for damaged case or glass. Clean the interior of the timers to remove all dust and dirt.	Be careful to avoid mechanical damage when cleaning the interior.
6	Terminal boards, posts, mountings.	W	Check terminal posts, mountings, machine screws, nuts, and connections for mechanical looseness.	
7	Resistors	W	Check resistors for blistering, discoloration, and other evidence of overheating.	
8	Capacitors	W	Check capacitors for bulges, and discoloration.	
9	Transformer	W	Check transformer for signs of excessive heating.	
10	Relay and buzzer	W	Make a visual inspection of the relay and buzzer sockets for loose connections, dirt, and corrosion.	
11	Metallic rectifiers	W	Check rectifiers for loose connections, dirt, and corrosion.	The vapors released by a burned-out metallic rectifier are poisonous. Wait until the room has been thoroughly aired. Avoid touching the burned-out section of the metallic rectifiers with bare hands.
12	Foot switch assembly	W	Check the foot switch for proper spring return action, satisfactory mechanical operation of switch, loose connections, and dirt.	

D—Daily; W—Weekly.

30. General

a. The second echelon repairman's duties consist of all preventive maintenance checks that are performed by the operator (par. 29) plus corrective maintenance that requires the replacement of the following parts:

(1) Electrical cables.
(2) Fixed capacitors.
(3) Plug connectors.
(4) Receptacle connectors.
(5) Telephone jacks.
(6) Telephone jack cover.
(7) Telephone ringing interrupter (buzzer).
(8) Vibration mounts.
(9) Binding posts.
(10) Fixed resistors.
(11) Toggle switches.
(12) Miscellaneous screws.

b. The unit repairman also lubricates the equipment as described in paragraph 28.

c. An equipment performance checklist (par. 34) is included in this section, as well as a paragraph describing the replacement of parts (par. 35).

31. Tools, Materials, and Test Equipment Required

The second echelon repairman has available the following tools and test equipment. The tools listed in paragraph 26 are also available for the performance of preventive maintenance.

Item	Used to—
Pliers TL–126	Help remove nuts and bolts.
Knife TL–29	Expedite replacement of electrical wiring.
Diagonal Cutters TL–103	Cut wires and to remove insulation from electrical wiring.
Screwdriver TL–385/U	Remove and replace all screws.
Soldering Iron TL–117	Solder electrical connections.
Wrench Set TL–483/U	Remove and replace all nuts.
Multimeter TS–297/U	Check electrical circuits.

32. Troubleshooting Procedures

a. Troubleshooting by the unit repairman is limited to the localizing of defective parts that are replaceable at the second echelon level. Replaceable items are listed in paragraph 30.

b. The techniques used for troubleshooting include visible inspection, operational tests, and simple continuity checks. When these techniques are not sufficient to determine the source of trouble, troubleshooting at field maintenance level (pars. 38–41) will be required.

c. When the equipment does not operate properly and the cause is not immediately apparent, check the items listed below and refer to paragraphs 33 and 34. Also, if possible, obtain information from the operator regarding performance of the equipment at the time trouble occurred. Failure of the equipment may be due to the following faults:

(1) Worn, broken, or disconnected electrical cables.
(2) Worn, loose, or broken plug and receptacle connectors.
(3) Fixed capacitors (C1 and C2) defective.
(4) Telephone ringing interrupter (buzzer Y1) defective or disconnected.
(5) Telephone jacks (J2 and J3) or binding posts (E3 and E4) loose, worn, or broken.
(6) Fixed resistors (R2 and R3) defective or broken.
(7) Switches (S1, S2, S3, and S4) shorted, disconnected, or damaged.
(8) Potentiometer (variable resistor R1) disconnected, damaged, or defective.

33. Troubleshooting Using Equipment Performance Checklist

a. General. The equipment performance checklist (par. 34) will help locate trouble in the equipment. This checklist gives the item to be checked, the action or condition under which it is checked, the normal indications of correct operation, and the corrective measures the unit repairman may take. To use the list effectively, always follow the items in their proper sequence.

b. Action or Condition. For some items, the information given in the action or condition column consists of various conditions under

which the item is to be checked. For other items, it represents an action that must be taken to check the normal indications given in the normal indication column.

c. Normal Indications. The normal indications listed include the visible signs that the unit repairman should perceive when checking the items. If the indications are not normal, the unit repairman should apply the recommended corrective measures.

d. Corrective Measures. The corrective measures listed are those that the unit repairman can make. If the equipment is completely inoperative, or if the recommended corrective measures do not yield results, turn in the equipment for repair.

34. Equipment Performance Checklist

	Item No.	Item	Action or condition	Normal indication	Corrective measures
PREPARATORY	1	Cables and headset.	Connect as described in paragraph 13.		
	2	CLOCKS ON-OFF switch.	Move the switch to OFF position.	All hands on timers should be stationary; buzzer should be silent.	Replace switch S2 (par. 35*h*).
START	3	CLOCKS ON-OFF switch.	Move switch to ON position.	The black hands on both timers should rotate.	Replace switch (S2) if neither timer operates (par. 35*h*).
				A 1,000-cycle tone should be heard.	Check rectifier CR1, transformer T1, capacitor C2, and buzzer Y1 (par. 29).
	4	VOLUME control.	Rotate for a comfortable listening level.		Replace defective part (par. 35) or turn in equipment for repair.
	5	30-SEC—60-SEC switch.	Move switch to 30-SEC position.	A 1,000-cycle, 7-second tone signal is heard every 30 seconds in headset.	Replace switch S3 (par. 35*h*).
OPERATION	6	Foot switch assembly.	Press and release foot switch twice; each time note the effect on both timer red hands.	Red hands should stop and go as described in paragraph 17*b*.	Replace foot switch (S1) assembly.
	7	30-SEC—60-SEC switch.	Move switch to 60-SEC position.	The 1,000-cycle tone should be heard every 60 seconds.	Replace switch S3 (par. 35*h*).
	8	VOLUME control. switch.	Turn the VOLUME control counterclockwise.	The volume should decrease.	Turn in equipment for replacement of potentiometer.
	9	CLOCKS ON-OFF	Move switch to OFF position.	All hands on both timers should stop.	Replace switch S2 (par. 35*h*).
	10	RESET switch.	Press and release switch.	All hands should reset as described in paragraph 17*c*.	Check switch S4 and rectifier CR2 (par. 29 and 35). Replace defective part or turn in equipment for repair.
STOP	11	CLOCKS ON-OFF switch.	Move switch to OFF position.	All hands should stop; buzzer should be silent.	Replace switch S2 (par. 35*h*).

35. Replacing Parts

a. Electrical Cables (W1 and W2) and Plug Connectors (P1, P2, and P3) (fig. 1).

(1) Replace with new cable, when the cable is worn and the insulation is frayed or damaged.

(2) Remove damaged or broken plug connectors by unscrewing the two screws that hold the cable wires to the plug connector.

(3) Replace with new plug connectors and secure the cable wires with the two screws.

b. Receptacle Connectors (J1 and J4) and Telephone Jacks (J2 and J3) (fig. 6).

(1) Remove damaged or broken receptacle connectors (power receptacle J1, foot switch receptacle J4, and telephone jacks J2 and J3) by unscrewing the screws that secure the receptacles to the carrying case and the jacks to the front panel.

(2) Replace with new ones and secure them to the carrying case or front panel with the screws.

c. Telephone Jack Cover (O 27) (fig. 6).

(1) Remove the damaged or broken telephone jack cover from the telephone jack by knocking out the pin which releases both the cover and the spring.

(2) Replace with a new cover and spring and secure them by driving in the pin.

d. Fixed Capacitors (C1 and C2) (fig. 7).

(1) Remove a damaged, broken, or defective capacitor by disconnecting the wiring and unscrewing the two screws that secure the capacitor to the chassis.

(2) Replace with a new capacitor and secure it to the chassis with the two screws.

(3) Connect the wiring to the capacitor.

e. Telephone Ringing Interrupter (Buzzer Y1) (fig. 7).

(1) The buzzer is mounted by a bakelite plate to the chassis. Remove a damaged or defective buzzer by unscrewing the two screws that hold the bakelite plate to the chassis.

(2) Disconnect the wires.

(3) Replace with a new buzzer and secure the bakelite plate to the chassis with the two screws.

(4) Connect the wires.

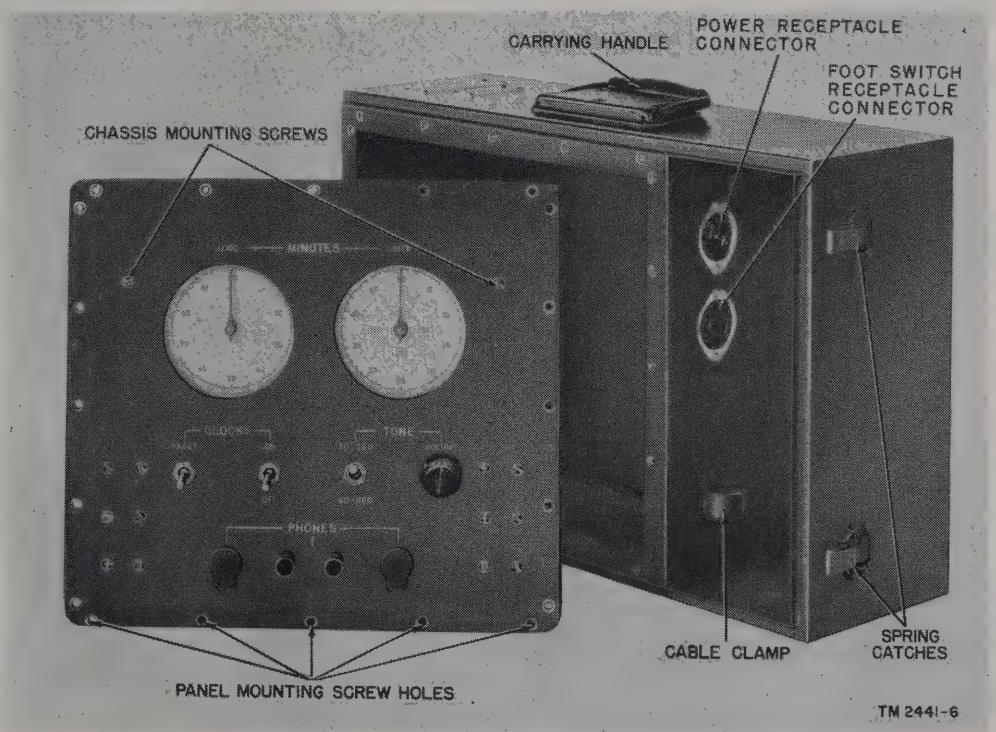


Figure 6. Front panel and chassis assembly, removed from carrying case.

f. Vibration Mounts (O 35, O 36, O 37 and O 38) (fig. 7).

(1) The four rubber vibration mounts cushion the chassis where it is connected to the carrying case. Replace a damaged or defective vibration mount by removing the chassis mounting nut and washer and by lifting off the vibration mount.

(2) Replace with a new vibration mount and secure it with the washer and nut.

g. Fixed Resistors (R2 and R3) (fig. 7).

(1) Replace a damaged or defective resistor by removing the two screws that secure the resistor to the chassis.

(2) Disconnect the wiring.

(3) Replace with a new resistor and secure to the chassis with the two screws.

(4) Connect the wiring.

h. Toggle Switches (S2, S3 and S4) (fig. 6).

(1) Replace a damaged or defective toggle switch by removing the retaining nut that secures it to the front panel.

(2) Disconnect the wiring; replace with a new toggle switch, and secure the switch to the front panel with the retaining nut.

(3) Connect the wiring.

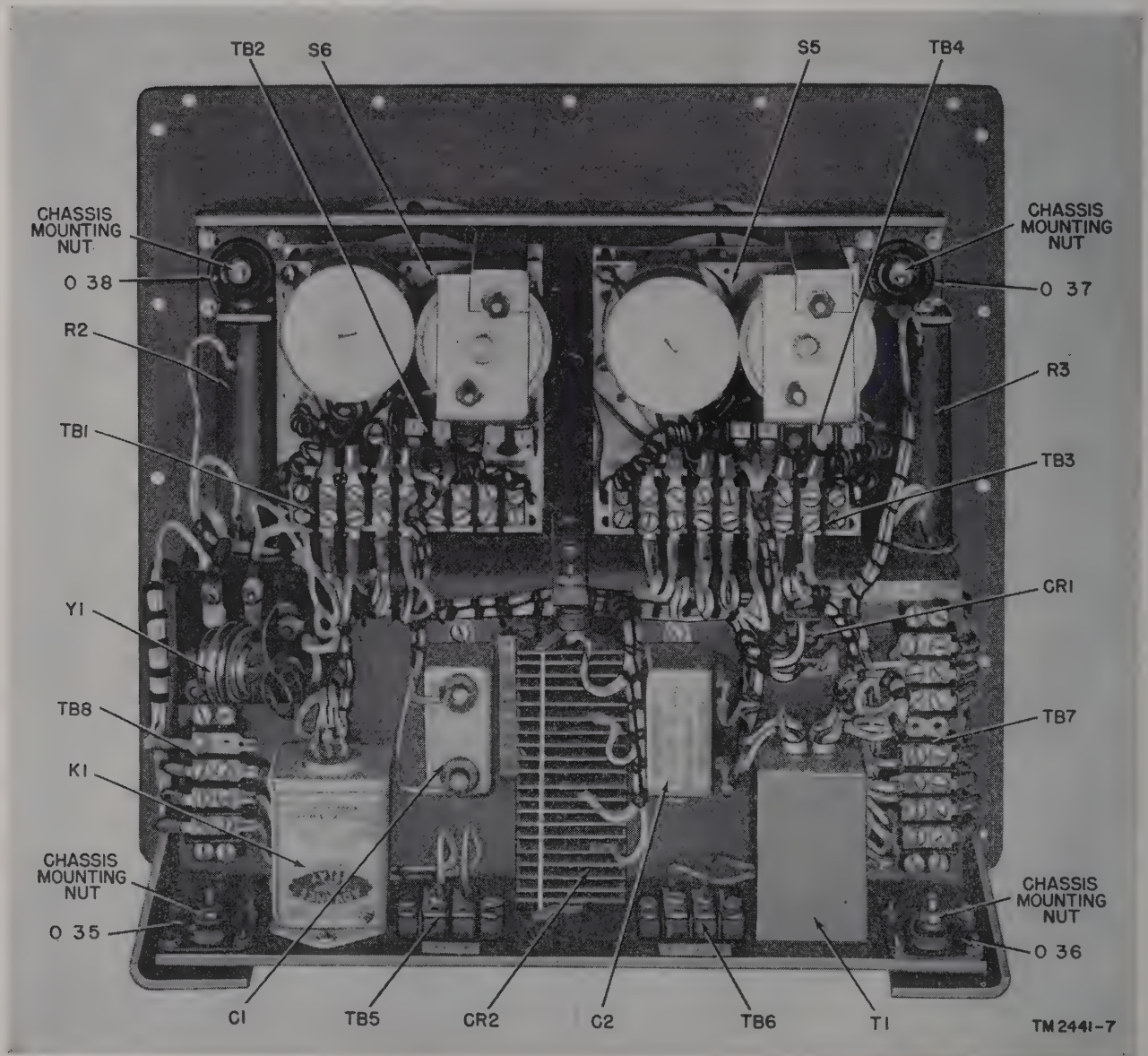


Figure 7. Front panel and chassis assembly, rear view.

CHAPTER 5
THEORY OF OPERATION

36. General
(fig. 8)

a. Timer Circuits.

(1) Time Signal Set ML–390/U is used to measure instantaneous (black hands) and delayed (red hands) time intervals. Two timers (S5 and S6) are provided for this purpose. Timer S5 (1/100) measures time in 1-minute intervals with 1/100-minute divisions. Timer S6 (UNITS) has two scales to measure 50-minute and 200-minute intervals, using 1-minute and 50-minute divisions, respectively. Both timers are synchronous so that when the black hand on the 1/100 timer rotates a full minute, the hand on the 50-minute scale (UNITS timer) advances 1 division and the hand on the 200-minute scale (UNITS timer) advances 1/50 division.

(2) Two sets of hands, black and red, are provided in each timer. The black hands rotate continuously when CLOCKS ON–OFF switch S2 is in the ON position. The black hands indicate the instantaneous time that has elapsed since the timer was set in motion. This is the instantaneous total time. The red hands are controlled by the foot switch assembly. When switch S1 is pressed down and released to open the circuit, the red hands are stopped and indicate the interval that elapsed from the moment the timer was set in motion to the moment the foot switch was pressed and released. This is the delayed total time.

(3) Before setting the timers in motion to measure a given interval, CLOCKS ON–OFF switch S2 is moved to the OFF position and the RESET switch S4 is pressed and released. This returns all hands to the start position.

b. Timing Signal, 1,000-cycle. The signal set also includes a 1,000-cycle buzzer that emits an audible signal when CLOCKS ON–OFF switch S2 is in the ON position. This signal is transmitted to PHONES jacks J2 and J3 through relay K1. This relay is actuated for a period of 7 seconds every 30 or 60 seconds (depending on the position of 30-SEC—60-SEC switch S3) by a cam included in timer S5.

37. Circuits Analysis
(fig. 9)

a. Dehumidifying Resistors R2 and R3. When connector plug P1 is connected to a 110- to 120-volt, 60-cycle power source, current flows through dehumidifying resistors R2 and R3. These 10-watt resistors heat the unit and dry out any excess moisture that may have accumulated during nonoperating periods.

b. CLOCKS ON–OFF Switch S2. When CLOCKS ON–OFF switch S2 is moved to the ON position, power is applied directly to the following circuits or elements:

(1) Motor B2 of timer S5.
(2) Black-hand electromagnet of timer S5.
(3) Cam contacts E1 and E2 of timer S5.
(4) Motor B1 of timer S6.
(5) Black-hand electromagnet of timer S6.
(6) Buzzer Y1 power supply.
(7) Foot switch S1.

c. Foot Switch S1. Foot switch S1 is a single-pole, single-throw push-on, push-off switch contained within the foot switch assembly. With CLOCKS ON–OFF switch S2 in the ON position, closing of foot switch S1 applies primary power to the red-hand electromagnets of both timers; this causes the red hand to rotate. When switch S2 is opened, primary power is removed from these electromagnets; this causes the hands to stop.

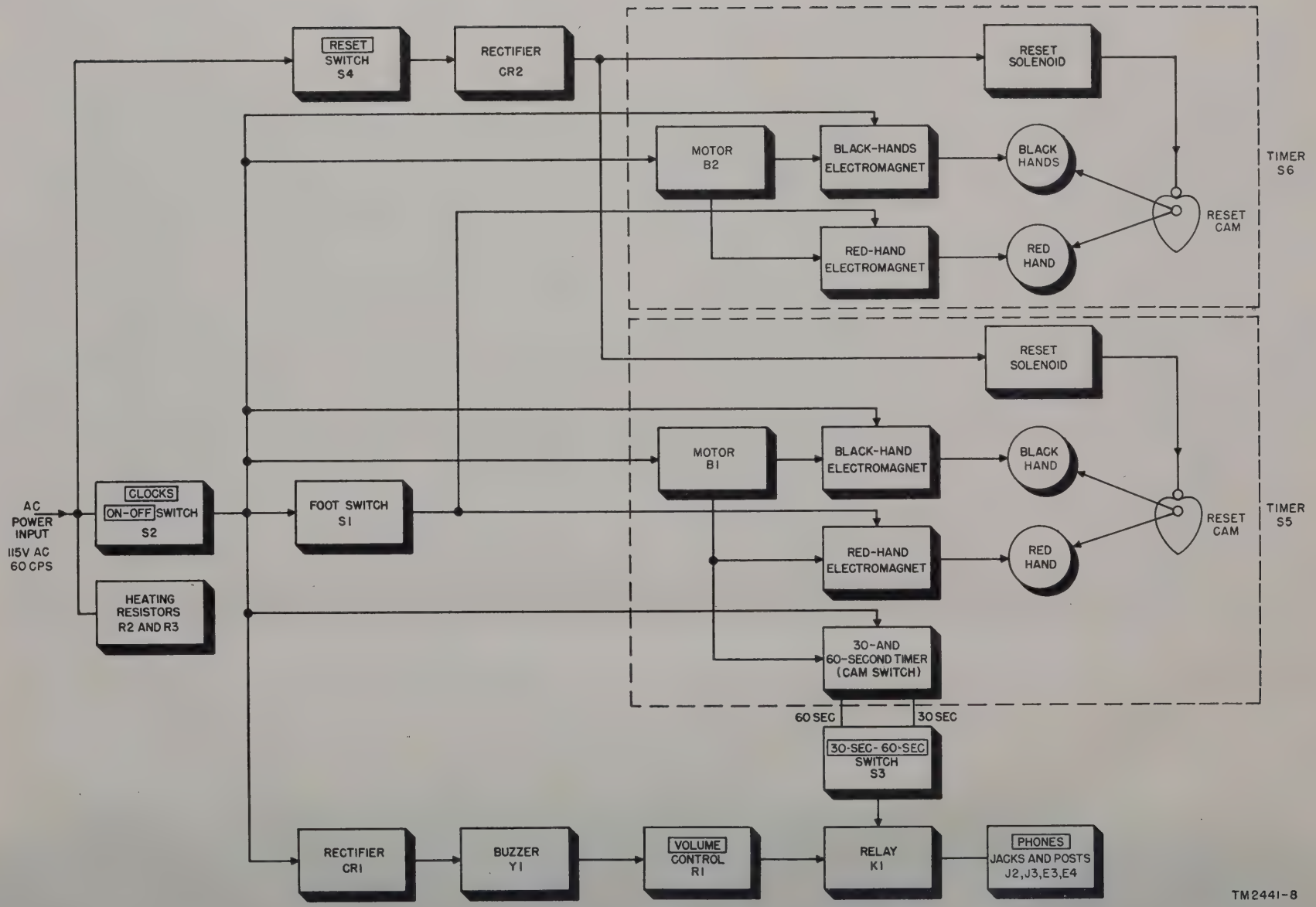


Figure 8. Time Signal Set ML–390/U, block diagram.

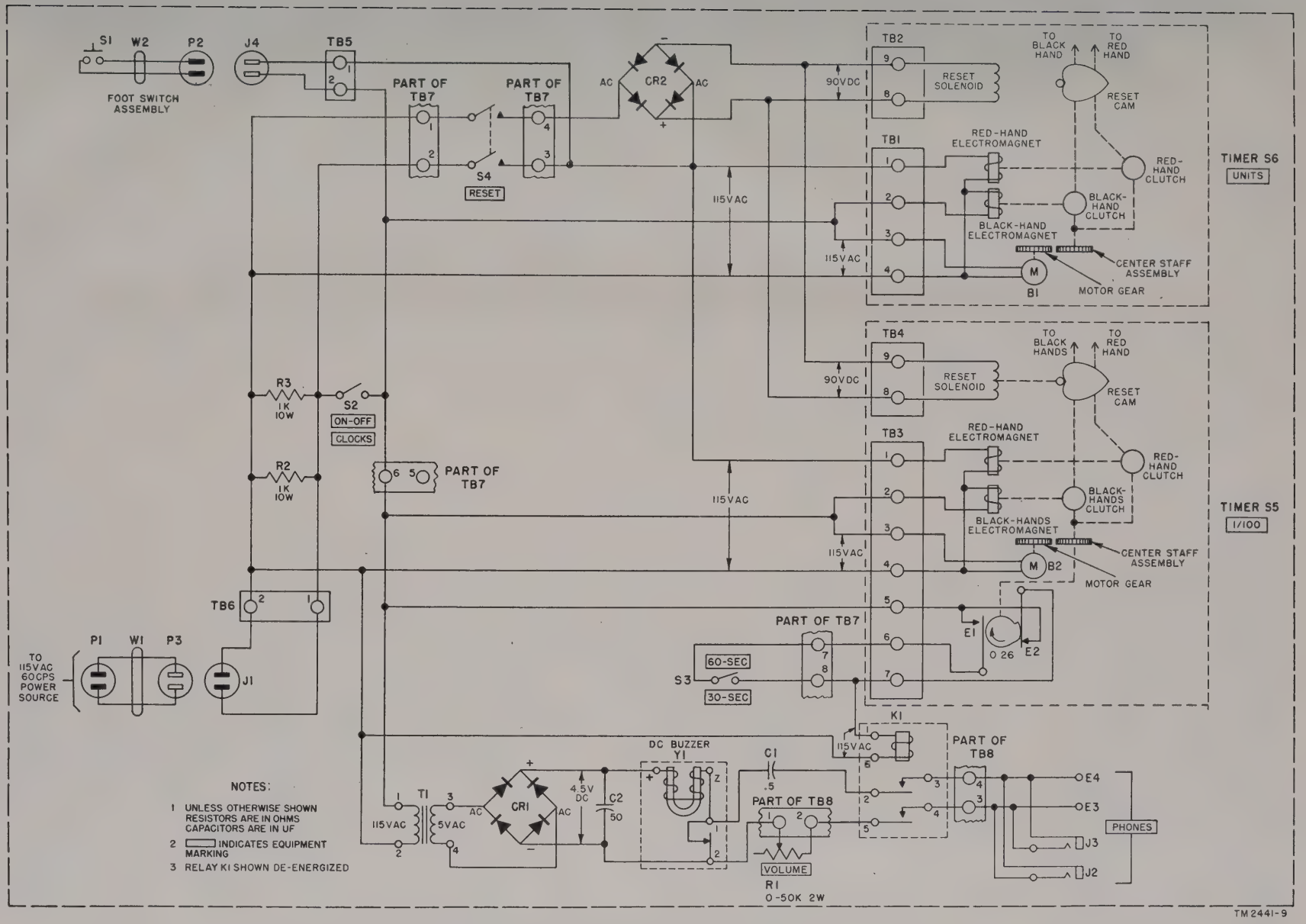


Figure 9. Time Signal Set ML–390/U, schematic diagram.

d. UNITS Timer S6 (fig. 10).

(1) *General.* When CLOCKS ON–OFF switch S2 is moved to the ON position (closed), primary power is applied to synchronous motor B1 of UNITS timer S6 through terminals 3 and 4 of terminal board TB1. This motor is coupled to the black- and red-hand shafts through the motor gear and a system of clutches (fig. 11).

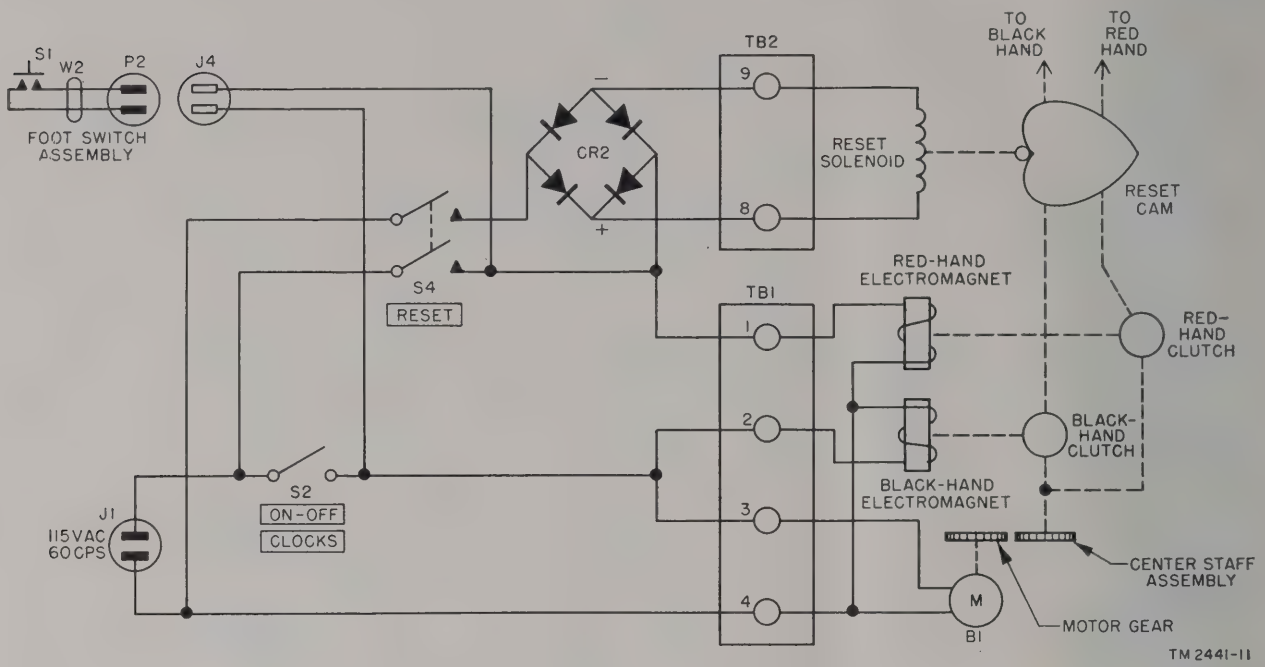


Figure 10. UNITS timer S6, schematic diagram.

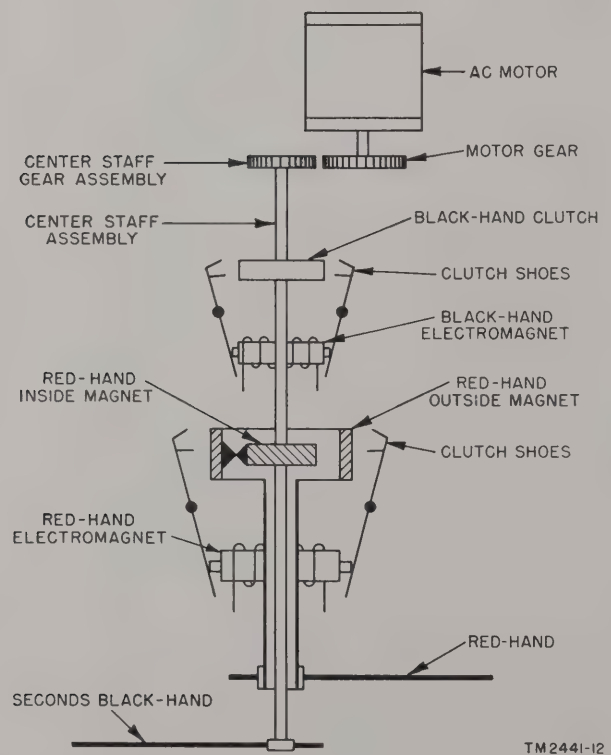


Figure 11. Black- and red-hand operation, simplified mechanical diagram.

(2) *Black hand.* When CLOCKS ON–OFF switch S2 is in the ON position (fig. 10), power is applied to the black-hand electromagnet (control magnet) through terminals 2 and 4 of terminal board TB1, and thus energizes the electromagnet. When the electromagnet is energized it pivots the clutch shoes (fig. 11) away from the black-hand clutch and permits the black hand to rotate. The black-hand clutch is connected to the center staff assembly with two friction springs that permit critical tensions (torques) for controlled drive or slippage (par. 47*c*). When CLOCKS ON–OFF switch S2 is in the OFF position, power is removed from the black-hand electromagnet (de-energizing the electromagnet), the clutch shoes engage the black-hand clutch, and the rotation of the black hand stops.

(3) *Red hand* (fig. 11).

(*a*) When foot switch S1 is pressed to open, the red-hand electromagnet (control magnet) is de-energized; this permits the clutch shoes to engage the red-hand outside magnet and stop the rotation of the red hand. Note that the black hand (and red hand inside magnet) continues to rotate.

(*b*) When foot switch S1 is pressed to close, power is applied to the red-hand electromagnet through terminals 1 and 4 of terminal board TB1 (fig. 10) and the elecrtomagnet becomes energized. When the red-hand electromagnet is energized, it pivots the clutch shoes away from the red-hand outside magnet (fig. 11) and thus permits the red-hand outside magnet (and red hand) to rotate freely. Note that the inside magnet is attached to the center staff assembly and rotates continuously with the black hand. The red-hand outside magnet rotates until it reaches the inside magnet; then they rotate together.

(4) *Totalizer black hand* (fig. 12). The operation of the totalizer black hand (small) is similar to that described for the seconds black hand (large) described in (2) above. A gear on the center staff assembly drives an intermediate gear and pinion assembly that drives the totalizer gear assembly to which the totalizer hand is attached (fig. 12). This intermediate gearing causes the small black hand to rotate once to every four times of the large black hand.

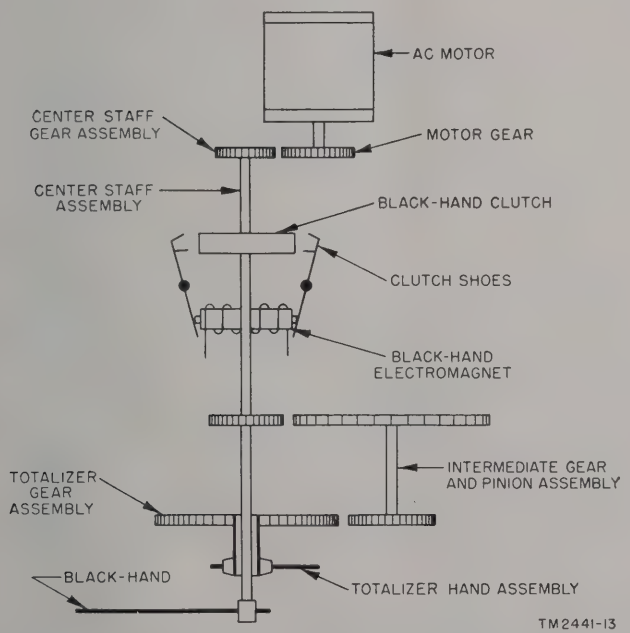


Figure 12. Totalizer (black small) hand operation, simplified mechanical diagram.

(5) *Reset mechanism* (fig. 13). RESET switch S4 (fig. 9) is normally open. When the switch is closed (moved up), primary power is applied across rectifier CR2; the direct current (dc) output of rectifier CR2 is applied to a reset rotary electrical solenoid in the timer. The solenoid shaft rotates, and pushes the reset bushing and arm assembly so that the arm engages the reset cam and resets the hands to zero. RESET switch S4 returns automatically to the open position when it is released, and thereby disconnects the power from the reset solenoid, which allows for normal operation of the timer.

e. Timer S5.

(1) *General.* The black seconds hand, the red spilt seconds hand, and the reset mechanism in this timer operate in the same manner as those in timer S6 (*d* above). Timer S5 also has a cam arrangement which pulses the 1,000-cycle timing signal ((*2*) below).

(2) *Timing signal, 1,000-cycle* (fig. 14).

(*a*) When CLOCKS ON–OFF switch S2 (fig. 14) is placed in the ON position, power is applied to the primary (terminals 1 and 2) of stepdown transformer T1. The secondary of this transformer (terminals 3 and 4) supplies 5 volts to bridge-type rectifier CR1. The rectified output is filtered by capacitor C2 and applied to the input terminals of dc buzzer Y1. The buzzer generates a 1,000-cycle (±20 percent) signal. The output of this buzzer is coupled through VOLUME control R1 and capacitor C1 to contacts 2 and 5 of

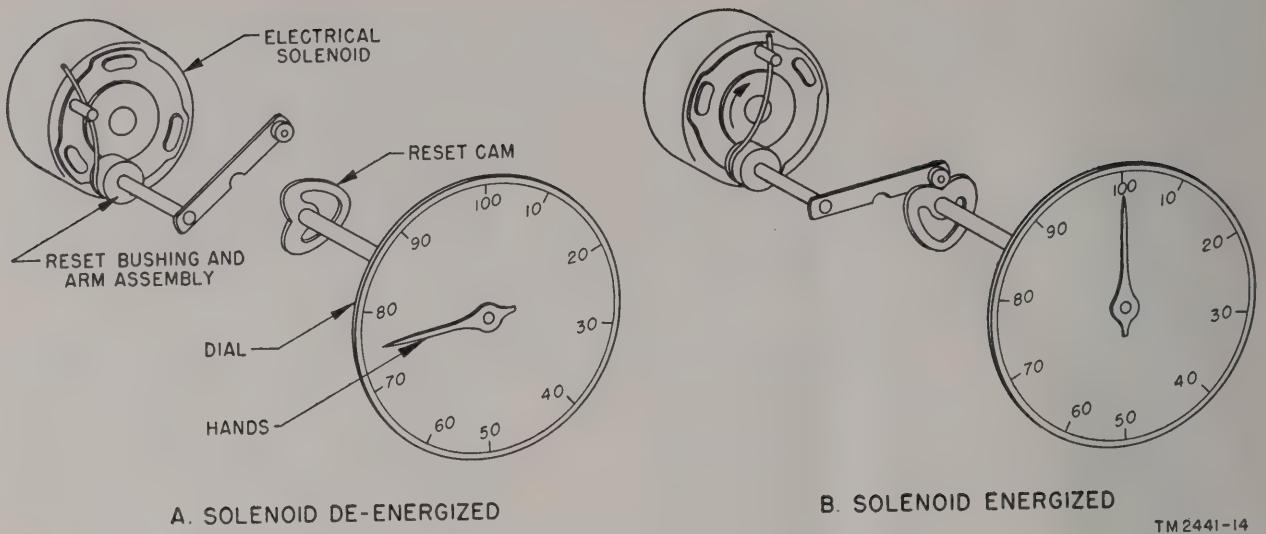


Figure 13. Reset mechanism, simplified mechanical diagram.

relay K1. When relay K1 is energized, the 1,000-cycle tone is fed through relay contacts 3 and 4 to PHONES jacks J2 and J3 and binding posts E3 and E4.

(*b*) Cam O 26 rotates at a rate of 1 revolution per minute and makes contacts E1 and contacts E2 once every revolution. The shape and speed of the impulse cam is such that contact with each contact block is made for approximately 7 seconds in each revolution.

(*c*) With CLOCKS ON–OFF switch S2 in the ON position, and 30-SEC—60-SEC switch S3 in the 30-SEC position (closed), relay K1 is energized twice in each minute (one revolution of cam O 26) : once when cam O 26 closes contacts E2 (for 7 seconds duration) to close the coil circuit of relay K2, and once when cam O 26 closes contacts E1 (for 7 seconds duration) to close the coil circuit of relay K1.

(*d*) With CLOCKS ON–OFF switch S2 in the ON position, and 30-SEC—60-SEC switch S3 in the 60-SEC position (open), relay K1 is energized once in each minute (one revolution of cam O 26). The coil circuit of relay K1 is closed only when cam O 26 closes contact E1 (for 7 seconds duration).

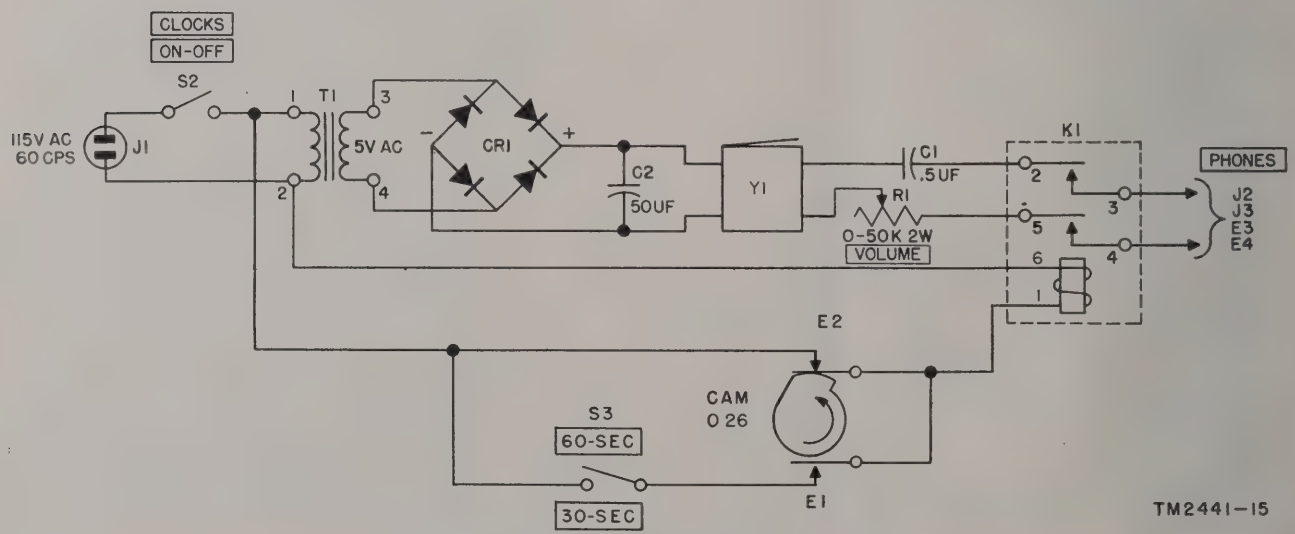


Figure 14. Tone signal circuit, schematic diagram.

CHAPTER 6

FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

38. Tools and Test Equipment Required

In addition to the tools and materials listed in paragraphs 26 and 31, the following tools and test equipment are required for troubleshooting and disassembling the ML–390/U:

Item	Used to—
Tool Equipment TE–49	Disassemble timers.
Multimeter TS–352/U	Check voltages.
Feeler gage, .0135-inch thick, 2L–391/U (Part of TE–49)	Provide proper tension when reassembling timers.
Test lamp or light bulb	Test cam and contacts.
Standard office clock	Check timer accuracy.

39. Troubleshooting Procedures

a. General. The first step in servicing a defective ML–390/U is to localize the faults to a particular circuit. The second step is to localize the fault to the defective part in that circuit. Some faults, such as burned-out resistors, shorted transformers, or broken gear teeth, can often be located by sight, smell, or hearing. Most faults must be localized by checking voltages and by continuity tests.

b. Component Sectionalization and Localization. The tests listed below will aid in isolating the fault. Follow the procedure in the order given. First, the trouble should be localized to a single circuit; then it may be isolated within the circuit by appropriate voltage and continuity measurements.

(1) *Visual inspection.* Visual inspection frequently reveals the stage in which the trouble exists. This inspection is valuable in forestalling future failures and in avoiding additional damage which might occur through improper servicing methods.

(2) *Voltage measurements.* Voltage measurements will often locate the defective component. Voltages are indicated on the overall schematic diagram (fig. 9).

(3) *Operational test.* The operational test frequently indicates the general location of the trouble and often determines the exact nature of the fault. All symptoms must be interpreted in relation to one another.

(4) *Troubleshooting chart.* The troubleshooting chart (par. 41) lists symptoms which will aid greatly in localizing troubles.

(5) *Intermittents.* In all these tests, the possibility of intermittents should not be overlooked. If present, this type of trouble can be detected by tapping or jarring the equipment.

40. Troubleshooting Data

Consult the following troubleshooting data when necessary.

Figure	Description
8	Block diagram of the equipment.
11, 12, and 13	Mechanical diagrams of the timers.
17, 19	Exploded views of timers S5 and S6.
9, 10, and 14	Schematic and partial diagrams.
20	Wiring diagram of the equipment.
6, 7, 15, and 16	Location of components.

41. Troubleshooting Chart

Symptom	Probable trouble	Checks	Correction
1. Resistors R2 and R3 do not warm up when power cable is plugged into power source.	No line voltage.	Measure line voltage. It should be 115 volts ac, ±10%.	
	Resistor R2 or R3 shorted or open.	Check for open or short circuit.	Replace resistor R2 or R3 (pars. 42*b* and 35*g*).
2. Timer hands rotate and buzzer sounds with CLOCKS ON-OFF switch S2 in the OFF position.	Switch S2 shorted.		Replace switch S2 (pars. 42*b* and 35*h*).
3. Timer hands do not rotate with CLOCKS ON-OFF switch S2 in the ON position.	Switch S2 defective.	Check for continuity across switch.	Replace switch S2 (pars. 42*b* and 35*h*).
	Motor B1 in UNITS timer S6 defective.	Check for 115 volts ac, ±10%, between terminals 3 and 4 of TB1.	Replace motor B1 (par. 45*d*).
	Motor B2 in 1/100 timer S5 defective.	Check for 115 volts ac, ±10%, between terminals 3 and 4 of TB3.	Replace motor B2 (par. 48*d*).
4. Black hand on 1/100 timer does not rotate, with CLOCK ON-OFF switch S2 in the ON position.	Motor B2 defective.	Check for 115 volts ac, ±10%, between terminals 3 and 4 of TB3.	Replace motor B2 (par. 48*d*).
	Black-hand electromagnet E4 defective.	Check for 115 volts ac, ±10%, between terminals 2 and 4 of TB3.	Replace the black-hand electromagnet E4 (par. 48*e*).
	Black-hand mechanical movement defective.	Check the black-hand mechanical movement for proper operation as illustrated in figure 12.	Replace any defective part (par. 48*e*).
5. Black hands on UNITS timer do not rotate with CLOCKS ON-OFF switch S2 in the ON position.	Motor B1 defective.	Check for 115 volts ac, ±10%, between terminals 3 and 4 of TB1.	Replace motor B1 (par. 45*d*).
	Black-hand electromagnet E6 defective.	Check for 115 volts ac, ±10%, between terminals 2 and 4 of TB1.	Replace black-hand electromagnet E6 (par. 45*e*).
	Black-hand mechanical movement defective.	Check the black-hand mechanical movement as illustrated in figures 12 and 13.	Replace any defective part (par. 45*e*).
6. Red hand on 1/100 timer does not rotate, with CLOCKS ON-OFF switch S2 in the ON position.	Motor B2 defective.	Check for 115 volts ac, ±10%, between terminals 3 and 4 of TB3.	Replace motor B2 (par. 48*d*).
	Red-hand electromagnet E3 defective.	Check for 115 volts ac, ±10%, between terminals 1 and 4 of TB3.	Replace red-hand electromagnet E3 (par. 48*d*).
	Red-hand mechanical movement defective.	Check the red-hand mechanical movement as illustrated in figure 12.	Replace any defective part (par. 48*d*).
7. Red hand on UNITS timer S6 does not rotate, with CLOCKS ON-OFF switch S2 in the ON position.	Motor B1 defective.	Check for 115 volts ac, ±10%, between terminals 3 and 4 of TB1.	Replace motor B1 (par. 45*d*).
	Red-hand electromagnet E5 defective.	Check for 115 volts ac, ±10%, between terminals 1 and 4 of TB1.	Replace red-hand electromagnet E5 (par. 45*d*).
	Red-hand mechanical movement defective.	Check the red-hand mechanical movement as illustrated in figure 12.	Replace any defective part (par. 45*d*).

Symptom	Probable trouble	Checks	Correction
8. Neither red hand stops although foot switch is pressed.	Foot switch assembly is defective.	Check foot switch S1.	Replace foot switch S1 if necessary (par. 43).
9. Red hands rotate, but do not snap behind the black hand when foot switch S1 is pressed.	Red-hand inside or outside magnets (fig. 12) defective.	Check the inside and outside magnets for magnetic interaction.	Replace the inside and/or outside magnet (par. 45*d*, *e*, and 48*d*, *e*).
	Red-hand electromagnet defective.	Check the applicable red-hand electromagnets as described in steps 6 and 7 above.	Replace the defective red-hand electromagnet (pars. 45*d* and 48*e*).
	Red-hand mechanical movement defective.	Check the red-hand mechanical movement as illustrated in figure 12.	Replace any defective part (pars. 45*d* and 48*e*).
10. All hands do not start return to start position when RESET switch S4 is deflected, with CLOCKS ON-OFF switch S2 in OFF position.	Switch S4 defective.	Check switch continuity.	Replace switch S4 (pars. 42*b* and 35*h*).
	Switch connections opened or shorted.		Tighten connections or replace defective wire.
	Metallic rectifier CR2 defective.	Check for 90 volts dc, ±10%, between terminals 8 and 9 of TB2 and TB4 (fig. 9).	Replace rectifier CR2 (par. 42*b*).
	Rotary reset solenoid defective (fig. 14).	Check for 90 volts dc, ±10%, between terminals 8 and 9 of TB2 and TB4.	Replace the applicable defective rotary reset solenoid (pars. 45*c* and 48*c*).
	Reset mechanical movement defective.	Check the reset mechanical movement as illustrated in figure 14.	Replace any defective part (pars. 45*c* and 48*c*).
11. No 1,000-cycle tone with CLOCKS ON-OFF switch S2 in the ON position.	Transformer T1 defective.	Check for 5-volt ac output across terminals 3 and 4 of transformer T1 (fig. 9).	Replace transformer T1 (par. 42*b*).
	Capacitor C2 defective.	Disconnect the capacitor and measure the resistance across it. It should exceed 5 megohms. Reconnect the capacitor (fig. 9).	Replace capacitor C2 (pars. 42*b* and 35*d*).
	Metallic rectifier CR1 defective.	Check for 4.5 volts dc, ±10%, output across the terminals of C2 (fig. 9).	Replace metallic rectifier CR1 (par. 42*b*).
	Buzzer Y1 defective.	Tap buzzer sharply several times with insulated end of screw driver.	Replace buzzer Y1 (pars. 42*b* and 35*e*) if 1,000-cycle tone is not heard.
	Relay K1 defective.	Check for 115 volts ac, ±10%, between terminals 1 and 6 of K1. During the time 115 volts are applied to pins 1 and 6 of K1, check for continuity between pins 2 and 3 and pins 4 and 5 (fig. 9).	Replace relay K1 (par. 42*b*).
	Potentiometer (variable resistor) R1 defective.	In its completely clockwise position, the resistance across the potentiometer should be zero (fig. 9).	Replace R1 (par. 42*b*).

Symptom	Probable trouble	Checks	Correction
	Capacitor C1 defective.	Measure the resistance across capacitor C1. An infinite meter reading should be obtained (fig. 9).	Replace C1 (pars. 42*b* and 35*d*).
	Contact block assembly E1 and/or E2 defective (fig. 9).	Check for proper operation of the particular contact block assembly as described in paragraph 50*g*.	Replace contact block assembly E1 or E2 as necessary (par. 48).
12. The tone signal is transmitted every 60 seconds instead of every 30 seconds when 30-SEC—60-SEC switch S3 is in the 30-SEC position.	Switch S3 defective.	Check switch S3 for continuity.	Replace switch S3 (pars. 42*b* and 35*h*).
	Contact block assembly E1 and/or E2 defective (fig. 9).	Check for proper operation of the particular contact block assembly as instructed in paragraph 50*g*.	Replace contact block assembly E1 or E2 as necessary (par. 48*c*).
13. The tone signal is transmitted everey 30 seconds instead of every 60 seconds when 30-SEC—60-SEC switch S3 is in 60-SEC position.	Same as item 12 above.	Same as item 12 above.	Same as item 12 above.

Section II. REPAIRS

42. Disassembly and Reassembly of Chassis

a. Removing Chassis from Carrying Case. To reach the internal parts on the chassis, remove it from its carrying case. Proceed as follows:

(1) Remove each of the 20 mounting screws around the outside of the front panel (fig. 6).

(2) For most maintenance purposes, it is preferable to leave the four wires in the carrying case connected to the terminals on the chassis. To make repairs, disconnect these four wires from terminal boards TB5 and TB6. Be sure to mark the wires with a tag or other device to avoid misconnection when the wires are reconnected.

b. Replacement of Parts on Chassis (fig. 7). All the parts on the chassis are readily accessible and easily replaced. If the part requires replacement, remove the machine screws that mount it to the chassis and disconnect the wires connected to it; mark each wire with a tag to avoid misconnection when a new part is installed.

Note. Buzzer Y1 is mounted to the chassis by a bakelite plate (fig. 7). When the buzzer has to be replaced, unscrew the two mounting screws and remove the entire assembly.

c. Reassembly Chassis to Carrying Case. To install the chassis in the carrying case, reverse the procedure described in *a* above.

43. Disassembly and Reassembly of Foot Switch Assembly

a. Disassembly. To disassemble the foot switch assembly (fig. 15), proceed as follows:

(1) Remove the two mounting screws that hold the pedal to the mounting and remove the pedal.

(2) To remove the spring, unscrew the two spring mounting screws.

(3) To remove the microswitch (foot switch S1), unscrew the two mounting screws and the holding nuts underneath the foot switch.

b. Reassembly. To reassemble the foot switch assembly, reverse the procedure outlined in *a* above.

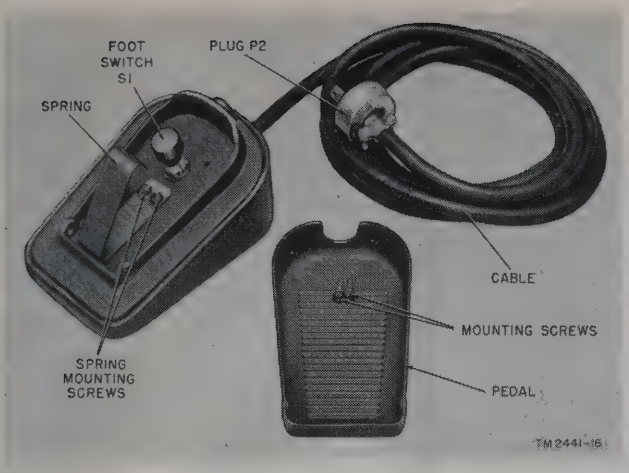


Figure 15. Foot switch, cover removed.

44. Removal and Replacement of Complete Timer Units (fig. 16)

a. Removal. To remove the timers from the chassis, proceed as follows:

(1) Remove the chassis from the carrying case (par. 42*a*).

(2) If timer S6 is to be removed, disconnect the wires from terminal boards TB1 and TB2 and tag each wire (fig. 7). If timer S5 is to be removed, disconnect the wires from terminal boards TB3 and TB4 and tag each wire.

(3) Turn the chassis on its side (fig. 16).

(4) Remove the chassis mounting nuts (fig. 7) that protrude through the shock mounts at the back of the chassis.

(5) Pull the chassis back from the front panel and position it as shown in figure 16.

(6) Remove the four timer mounting screws from the defective timer.

Caution: Hold the timer in one hand while removing the mounting screws with the other hand; these screws are the only support for the timer.

(7) If a new timer is not installed immediately after removing the defective timer, swing the chassis back into position and replace the mounting screws and nuts.

b. Replacement. To replace a complete timer or to install a new one, reverse the procedure described in *a* above.

45. Disassembly of Timer S6 (fig. 17)

Refer to figure 20. Remove and tag the *lower* leads from terminals 1, 2, 3, and 4 of terminal board TB1, and from terminals 8 and 9 of terminal board TB2. This will disconnect the timer from all circuits of the signal set. Remove the four No. 6–32 by $\frac{3}{8}$-inch long mounting screws (fig. 16) that secure timer S6 to the front panel, and remove the complete timer assembly as described in paragraph 44.

a. Red and Black Pointers.

(1) Unscrew the one mounting screw (1, fig. 17) from the shaft of the center staff assembly (47) and remove the lockwasher (2) and the black pointer (3).

(2) Unscrew the hexagonal nut (4) and pull off the red pointer (5) from the shaft of the center staff assembly (47).

b. Parts, Front of Front Plate (51).

(1) Unscrew the two mounting screws (7) that hold the dial (8) to the pillars on the front plate (51).

(2) Open the fingers of the friction spring (43) that holds the totalizer reset cam assembly (9) and remove the dial (8) together with the totalizer hand assembly (6) and the totalizer reset cam assembly (9). Note that these two assemblies (6 and 9) are press-fitted together. If necessary, separate these two assemblies from the dial (8).

(3) Unscrew the two screws (10) and lockwashers (11) that mount the intermediate gear bracket (12) to the front plate (51).

(4) Remove the intermediate gear bracket (12) and the intermediate gear and pinion assembly (13) from the front plate (51).

c. Parts, Front and Back Plates (51) and (103).

(1) Unscrew the two screws (14) and lockwashers (15) that hold the terminal board (16) to the solenoid

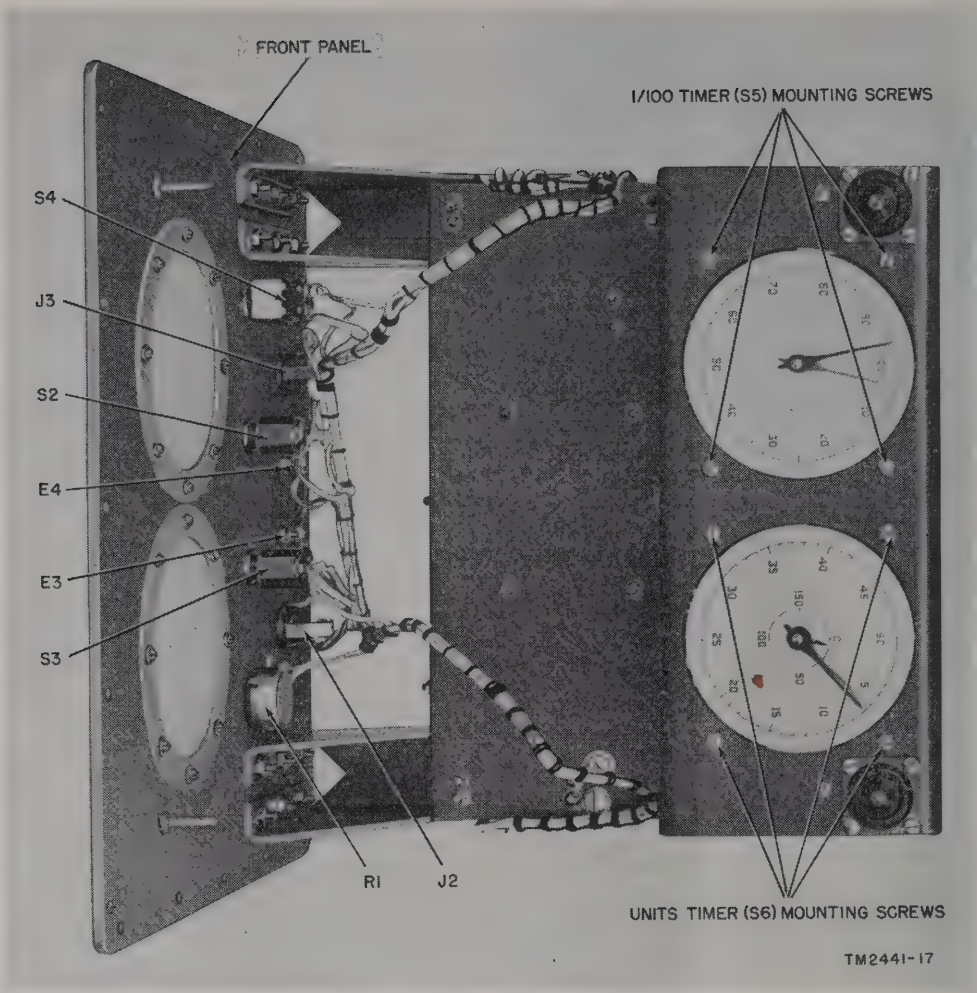


Figure 16. Front panel and chassis assembly, front panel swung back.

bracket (20) and pull the terminal board (16) away from the solenoid bracket (20). Remove and tag the two leads from the rotary solenoid (21) to terminals 8 and 9 of the terminal board (16).

(2) Unscrew the hexagonal nut (17) and lockwasher (18) that hold the solenoid bracer (19) and the solenoid bracket (20) to the rotary solenoid (21).

(3) Remove the cotter pin (23) and plain washer (22) from the rear of the rotary solenoid (21).

(4) Unscrew the screw (24) and lockwasher (25) from the hexagonal nut (26) and remove the solenoid bracer (19) from the front plate (51).

(5) Unscrew the two screws (27) and lockwashers (28) from the back plate (103) and pull out the assembly of the rotary solenoid (21), the solenoid bracket (20) and the terminal board (16).

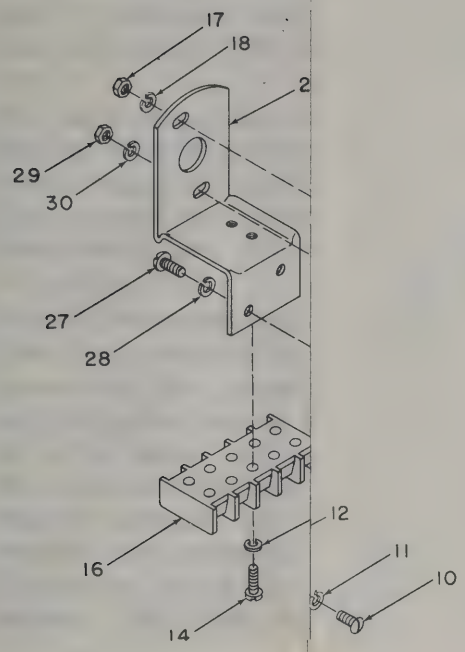
(6) Unscrew the hexagonal nut (29) and lockwasher (30) from the rotary solenoid (21) and remove the solenoid bracket (20) from the rotary solenoid.

(7) Loosen the setscrew (31) and pull out the reset actuating arm (32).

(8) Knock out the taper pin (33) with a drift pin. Note that this is a taper pin and should be knocked out in the direction opposite to the taper.

(9) Loosen the setscrew (34) and pull the reset arm bushing (35) off from the totalizer reset arm assembly (38).

(10) Knock out the taper pin (36) from the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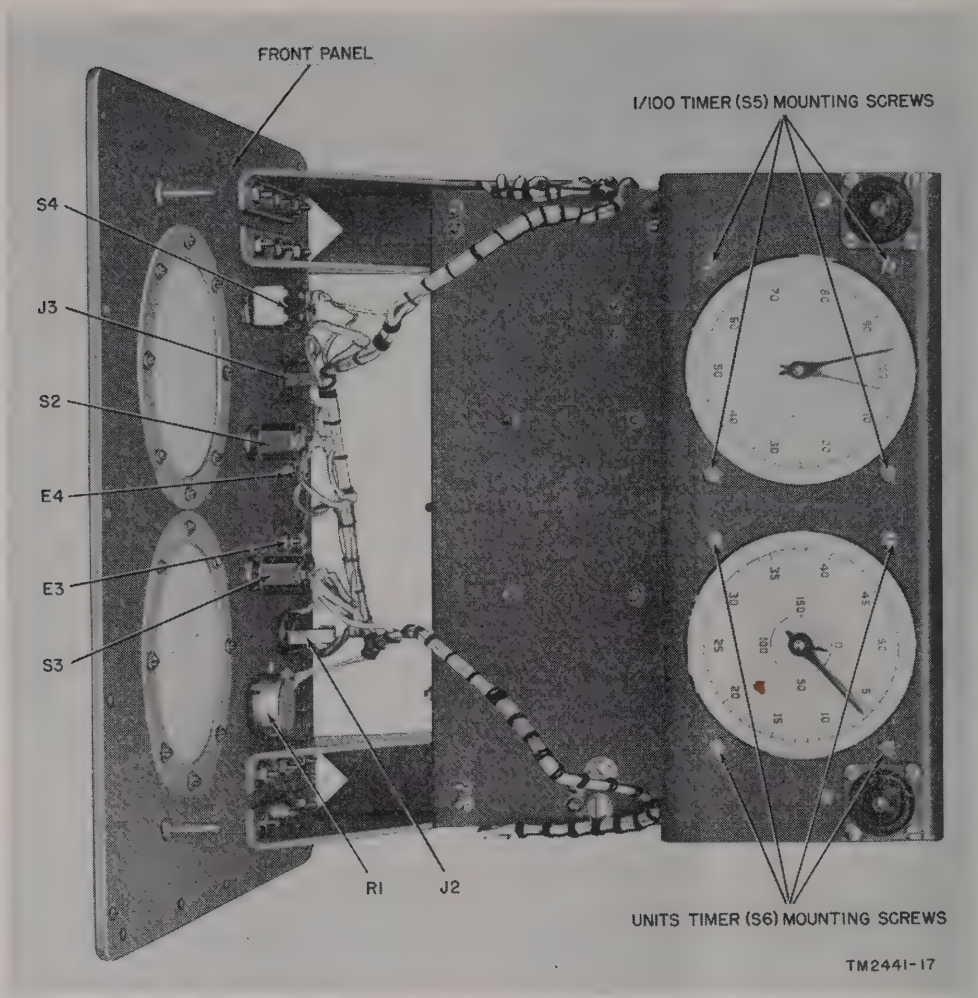


Figure 16. Front panel and chassis assembly, front panel swung back.

bracket (20) and pull the terminal board (16) away from the solenoid bracket (20). Remove and tag the two leads from the rotary solenoid (21) to terminals 8 and 9 of the terminal board (16).

(2) Unscrew the hexagonal nut (17) and lockwasher (18) that hold the solenoid bracer (19) and the solenoid bracket (20) to the rotary solenoid (21).

(3) Remove the cotter pin (23) and plain washer (22) from the rear of the rotary solenoid (21).

(4) Unscrew the screw (24) and lockwasher (25) from the hexagonal nut (26) and remove the solenoid bracer (19) from the front plate (51).

(5) Unscrew the two screws (27) and lockwashers (28) from the back plate (103) and pull out the assembly of the rotary solenoid (21), the solenoid bracket (20) and the terminal board (16).

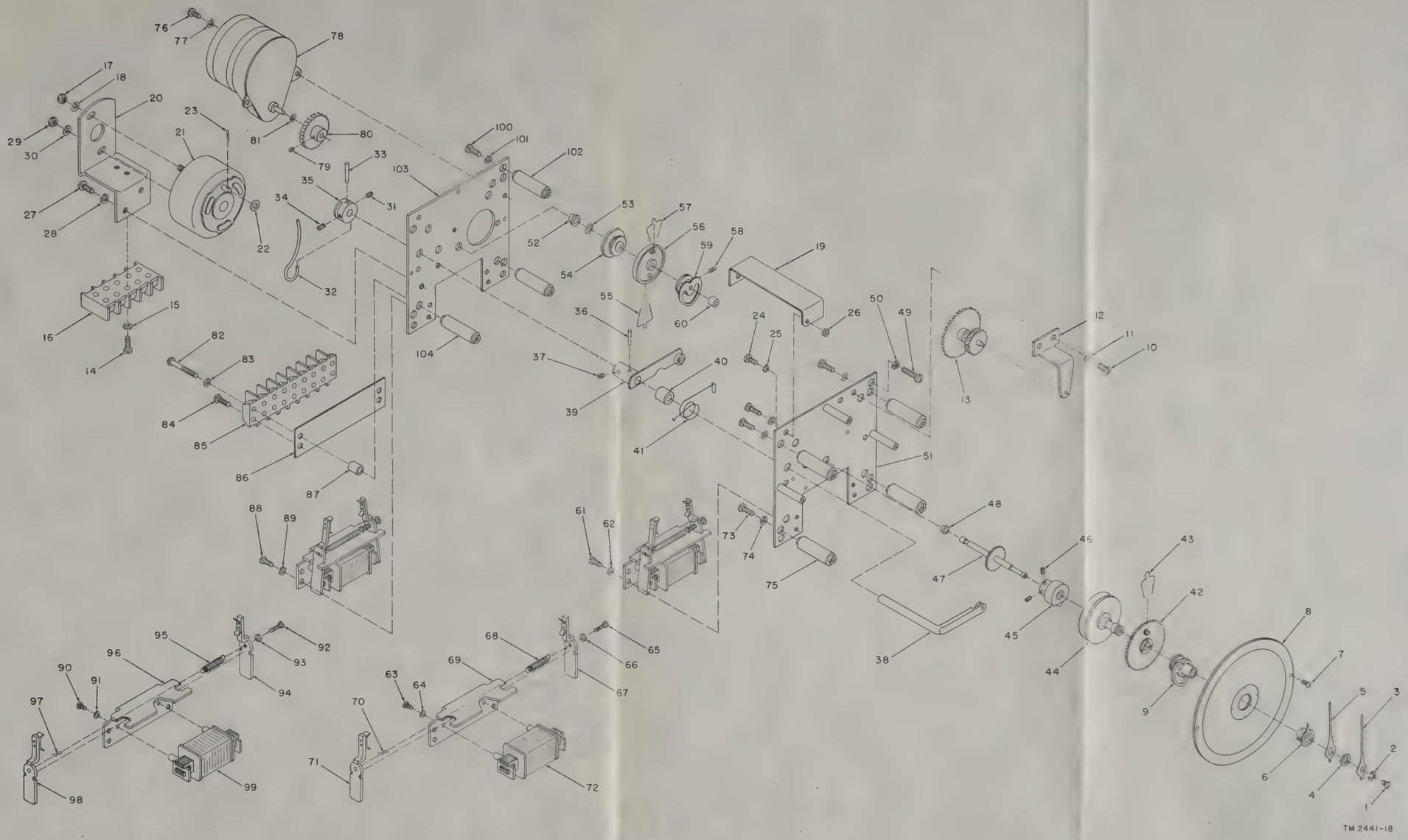
(6) Unscrew the hexagonal nut (29) and lockwasher (30) from the rotary solenoid (21) and remove the solenoid bracket (20) from the rotary solenoid.

(7) Loosen the setscrew (31) and pull out the reset actuating arm (32).

(8) Knock out the taper pin (33) with a drift pin. Note that this is a taper pin and should be knocked out in the direction opposite to the taper.

(9) Loosen the setscrew (34) and pull the reset arm bushing (35) off from the totalizer reset arm assembly (38).

(10) Knock out the taper pin (36) from the



1 Machine screw; roundhead, #2–56 by $\frac{1}{16}$ inch long.
2 Lockwasher; for #2 screw.
3 Seconds hand (O 21).
4 Split seconds hand retaining nut; #10–48.
5 Split seconds hand (O 22).
6 Totalizer hand assembly (O 23).
7 Machine screws binding head, #2–56 by $\frac{1}{16}$ inch long.
8 Dial; aluminum, $3\frac{1}{16}$ inch, $\frac{13}{32}$ inch inside diameter .020 inch thick.
9 Cam assembly (totalizer reset); brass and steel, $\frac{13}{64}$ inch wide, $\frac{7}{8}$ inch high, .449 inch long.
10 Machine screw; roundhead, #8–32 by ¼ inch long.
11 Lockwasher; for #8 screw.
12 Intermediate gear bracket; brass, $\frac{7}{8}$ inch wide, .812 inch high, $1\frac{7}{16}$ inch long.
13 Intermediate gear and pinion assembly (O 14).
14 Machine screw; roundhead, #6–32 by ⅜ inch long.
15 Lockwasher; for #6 screw.
16 Terminal board (TB4).
17 Hexagonal nut; #8–32.
18 Split washer; for #8 screw.
19 Solenoid bracer; brass, 2.745 inch long, ¾ inch wide, .56 inch high.
20 Solenoid bracket; steel, 3 inch long, 1¼ inch wide, .075 inch thick.
21 Rotary electrical solenoid (L2).
22 Plain washer; brass, ⅜ inch .147 inch inside diameter, $\frac{1}{32}$ inch thick.
23 Cotter pin; $\frac{1}{32}$ inch diameter by ⅝ inch long.
24 Machine screw; roundhead, #6–32 by ⅜ inch long.
25 Lockwasher; for #6 screw.
26 Hexagonal nut; #6–32.
27 Machine screw; roundhead, stainless steel, #8–32 by ¼ inch long.
28 Lockwasher; for #8 screw.
29 Hexagonal nut; #8–32.
30 Lockwasher; for #8 screw.
31 Setscrew; Allen head, #4–40 by ⅛ inch long; part of O 19.
32 Reset actuating arm; $\frac{1}{16}$ inch outside diameter 1⅝ inch long overall; part of O 19.
33 Taper pin; #5/0 by ½ inch long.
34 Setscrew; Allen head, #4–40 by ⅛ inch long; part of O 19.
35 Reset arm bushing; $\frac{7}{16}$ inch wide, $\frac{7}{16}$ inch high, ¼ inch deep; part of O 19.
36 Taper pin; #5/0 by ½ inch long.
37 Setscrew; Allen head, #6–32 by ⅛ inch long.
38 Arm assembly (totalizing reset); $2\frac{7}{16}$ inch long, 1¾ inch wide, ¼ inch high.
39 Arm assembly (seconds reset); ⅞ inch wide, 2 inch long, ⅜ inch high.
40 Reset arm spacer; $\frac{1}{16}$ inch outside diameter, .189 inch inside diameter, .323 inch long.
41 Reset spring (O 17).
42 Totalizer gear assembly (O 10).
43 Friction spring (O 16).
44 Magnet cup assembly; 1.25 inch outside diameter, .963 inch long.
45 Magnet assembly (inside); ⅝ inch outside diameter, .452 inch long.
46 Setscrew; Allen head, #4–40 by ⅛ inch long.
47 Center staff assembly (O 11).
48 Center staff bushing; oilite bronze .238 inch outside diameter, .1885 inch inside diameter, ⅛ inch long.
49 Machine screw; roundhead, #6–32 by ¼ inch long.
50 Lockwasher; for #6 screw.
51 Front plate; brass, 3¾ inch long, 3¾ inch wide, ⅛ inch thick.
52 Center staff bushing; oilite bronze, .238 inch outside diameter, .1885 inch inside diameter, ⅛ inch long.
53 Friction center staff washer (O 24).
54 Gear assembly (center staff) (O 12).
55 Friction spring (O 16).
56 Control disk assembly (O 25).
57 Friction spring (O 16).
58 Setscrew; Allen head, #4–40 by ⅛ inch long.
59 Cam assembly (seconds reset); $\frac{13}{16}$ inch high, ¾ inch wide, ¼ inch long.
60 Center staff spacer; $\frac{1}{16}$ inch outside diameter, $\frac{1}{16}$ inch inside diameter, ⅜ inch long.
61 Machine screw; fillister head, #4–40 by ¼ inch long.
62 Lockwasher; for #4 screw.
63 Machine screw; roundhead, #4–40 by $\frac{1}{16}$ inch long.
64 Plain washer; brass, ¼ inch outside diameter, ⅛ inch inside diameter, .020 inch thick.
65 Armature adjusting screw; roundhead, #4–48 by ⅝ inch long, #65 hole near end.
66 Hexagonal nut; brass, #4–48.
67 Armature assembly (front left); $1\frac{13}{16}$ inch long, ⅜ inch wide.
68 Armature adjusting spring (O 20).
69 Armature bracket; 2½ inch long, $\frac{13}{32}$ inch wide, $\frac{13}{64}$ inch high.
70 Cotter pin; $\frac{1}{16}$ inch diameter by ½ inch long.
71 Armature assembly (front right); $1\frac{13}{16}$ inch long, ⅜ inch wide.
72 Control magnet assembly (E5).
73 Machine screw; round head, #6–32 by ¼ inch long.
74 Lockwasher; for #6 screw.
75 Movement mounting pillar; $\frac{1}{16}$ inch outside diameter, 1.296 inch long overall.
76 Machine screw; #4–40 by $\frac{1}{16}$ inch long.
77 Lockwasher; for #4 screw.
78 Motor (B1).
79 Setscrew; Allen head, #4–40 by ⅛ inch long.
80 Motor gear assembly (O 13).
81 Center staff friction washer (O 24).
82 Machine screw; roundhead, #6–32 by ⅝ inch long.
83 Lockwasher; for #6 screw.
84 Machine screw; roundhead, #6–32 by ⅜ inch long.
85 Terminal board (TB3).
86 Terminal board plate; 3⅜ inch long, ⅞ inch wide, .025 inch thick.
87 Terminal board spacer; ¼ inch outside diameter, .1695 inch inside diameter, $\frac{3}{32}$ inch long.
88 Machine screw; fillister head, #4–40 by ¾ inch long.
89 Lockwasher; for 4 screw.
90 Machine screw; roundhead, #4–40 by $\frac{1}{16}$ inch long.
91 Plain washer; ¼ inch outside diameter, ⅛ inch inside diameter, .020 inch thick.
92 Armature adjusting screw; roundhead, #4–48 by ⅝ inch long, #65 hole in end.
93 Hexagonal nut; #4–48.
94 Armature assembly (back right); $1\frac{13}{16}$ inch long, .460 inch wide.
95 Armature adjusting spring (O 18).
96 Armature bracket; 2½ inch long, $\frac{13}{64}$ inch wide, $\frac{13}{32}$ inch high.
97 Cotter pin; $\frac{1}{16}$ inch diameter, ½ inch long.
98 Armature assembly (back left); $1\frac{13}{16}$ inch long, .460 inch wide.
99 Control magnet assembly (E6).
100 Machine screw; roundhead, #6–32 by ¼ inch long.
101 Lockwasher; for #6 screw.
102 Main pillar; $\frac{1}{16}$ inch outside diameter, .113 inch inside diameter, 1.167 inch long.
103 Back plate; 3¾ inch long, 3¾ inch wide, ⅛ inch thick.
104 Main pillar; $\frac{1}{16}$ inch outside diameter, .113 inch diameter, 1.167 inch long.

Figure 17. Units (three hand) timer S6, exploded view.

seconds reset arm assembly (39). Note that this too is a tapered pin.

(11) Loosen the two setscrews (37), pull out the totalizer reset arm assembly (38) from the seconds reset arm assembly (39), and remove the seconds reset arm spacer (40) and the spring (41).

(12) Pull the totalizer gear assembly (42) together with the friction spring (43) off the magent cup assembly (44), and then separate the friction spring (43) from the totalizer gear assembly (42) by pulling it off.

(13) Pull off the magnet cup assembly (44) from the center staff assembly (47).

(14) Loosen the two setscrews (46) and pull the inside magnet assembly (45) off of the center staff assembly (47). Note the magnetic pull of the inside magnet assembly on the Allen-head wrench when loosening the setscrews.

(15) If necessary, knock out the center staff bushing (48) from its hole in the front plate (51).

(16) Unscrew the four screws (49) and lockwashers (50) that hold the front plate (51) to the four pillars on the back plate (103) and separate the front and back plate assemblies to the maximum distance allowed by the two leads from the control magnet assembly (72).

(17) Remove and tag one lead from the control magnet assembly (72) to terminal 1 of the terminal board (85) and the other lead from the control magnet assembly to the screw-type splice cap alongside the rotary solenoid (21), and completely separate the front and back plate assemblies.

(18) Pull off the center staff friction washer (53) from the shaft of the center staff assembly (47).

(19) Spread apart the two fingers of the friction spring (55) and pull it out from its groove in the center staff gear assembly (54). Remove the gear assembly (54) from the control disk assembly (56).

(20) Spread apart the two fingers of the friction spring (57) and pull the spring out from its groove in the seconds reset cam assembly (59); remove the control disk assembly (56).

(21) Pull off the two friction springs (55 and 57) from their respective pins on the control disk assembly (56). Tag the springs clearly since there are three such springs in the timer, each of which is preset to a different spring tension.

(22) Loosen the two setscrews (58) and pull the seconds reset cam assembly (59) and the center staff spacer (60) off the shaft of the center staff assembly (47).

(23) If necessary, knock out the center staff bushing (52) from its hole in the back plate (103).

(24) Unscrew the four screws (61) and lockwashers (62) that hold the control magnet assembly (72) to the front plate (51) and remove the assembly.

d. Control Magnet Assembly (72) and Motor (78).

(1) Unscrew the two screws (63) and plain washers (64) and remove the control magent assembly (72) from the bracket 69.

Note. Do not disassemble the control magnet assembly (72) any further since the magnet core is ground after assembly. If necessary, replace the entire control magnet assembly as a unit.

(2) Detach the armature adjusting spring (68) from between the armature adjusting screw (65) and the cotter pin (70).

(3) Pull out the right front armature assembly (67) (together with the armature adjusting screw (65) and the hexagonal nut (66)) from the notch in the bracket (69).

(4) Loosen the hexagonal nut (66) and unscrew the armature adjusting screw (65) from the right-front armature assembly (67).

(5) Pull out the left-front armature assembly (71) (with the cotter pin (70)) from the notch in the bracket (69) and pull out the cotter pin (70) from the assembly (71).

(6) Unscrew the four screws (73) and lockwashers (74) and remove the four movement mounting pillars (75).

(7) Unscrew the two screws (76) and lockwashers (77) that hold the motor (78) to the back plate (103) and pull away the motor to the maximum distance allowed by the two motor leads.

(8) Remove and tag the one motor lead from terminal 3 of the terminal board (85) and the other lead from the screw-type splice cap alongside the motor. Remove the motor.

(9) Loosen the two setscrews (79) and pull the motor gear (80) and the center staff friction washer (81) off the shaft of the motor (78).

(10) Unscrew the two screws (82) and lockwashers (83) from the two main pillars (104). Pull out the screws (82) and lockwashers (83) from the terminal block spacers (87), the terminal board plate (86), and the terminal board (85), and remove the plate (86) and the board (85) together.

(11) Unscrew the two screws (84) and separate the terminal board (85) from the terminal board plate (86).

e. Control Magnet Assembly (99).

(1) Unscrew the four screws (88) and lockwashers (89) that hold the control magnet assembly (99) and (96) to the back plate (103) and remove the control magnet assembly (99) and bracket (96).

(2) Unscrew the two screws (90) and plain washers (91) mounting the control magnet assembly (99) by the spacers to the bracket (96) and remove the magnet assembly (99). Do not disassemble the magnet any further (*d*(1) above).

(3) Detach the armature adjusting spring (95) from between the armature adjusting screw (92) and the cotter pin (97).

(4) Pull out the right-rear assembly (94) (together with the armature adjusting screw (92) and the hexagonal nut (93)) from the notch in the bracket (96).

(5) Loosen the hexagonal nut (93) and unscrew the armature adjusting screw (92) from the right-rear armature assembly (94).

(6) Pull out the left-rear armature assembly (98) (together with the cotter pin (97)) from the notch in the bracket (96) and pull out the cotter pin (97) from the assembly (98).

(7) Unscrew the two screws (100) and lockwashers (101) from the two top main pillars (102) and remove the pillars from the back plate (103).

46. Reassembly of Timer S6 (fig. 17)

To reassemble timer S6, proceed as follows:

a. Control Magnet Assembly (99).

(1) Mount the two top main pillars (102) to the back plate (103) with the two machine screws (100) and lockwashers (101).

(2) Replace the cotter pin (97) in the left-rear armature assembly (98) and insert the assembly (and cotter pin (97)) into the left notch in the armature bracket (96).

(3) Screw the armature adjusting screw (92) midway into the right-rear assembly (94) and tighten it to the assembly with the hexagonal nut (93).

(4) Insert the entire assembly (94 with 92 and 93) into the right notch in the armature bracket (96).

(5) Attach the armature adjusting spring (95) between the armature adjusting screw (92) and the cotter pin (97).

(6) Mount the control magnet assembly (99) by its two spacers to the armature bracket (96) with the two machine screws (90) and plain washers (91).

(7) Screw the control magnet assembly (99) and armature bracket (96) to the back plate (103) with the four machine screws (88) and lockwashers (89).

b. Control Magnet Assembly (72) and Motor (78).

(1) Attach the terminal board (85) to the terminal board plate (86) with the two machine screws (84).

(2) Mount the terminal board (85) and the terminal board plate (86) to the back plate (103) with the terminal board spacers (87) by screwing the two machine screws (82) and lockwashers (83) through the back plate into the two main pillars (104).

(3) Insert the center staff friction washer (81) and the motor gear assembly (80) onto the shaft of the motor (78) and tighten the two setscrews (79).

(4) Connect one lead from the motor (78) to terminal 3 of the terminal board (85), and the other lead to the screw-type splice cap alongside the motor.

(5) Mount the motor (78) to the back plate (103) with the two machine screws (76) and lockwashers (77).

(6) Mount the four movement mounting pillars (75) to the front plate (51) with the four machine screws (73) and lockwashers (74).

(7) Replace the cotter pin (70) in the left-front armature assembly (71) and insert the armature assembly (71) (and cotter pin (70)) into the left notch in the armature bracket (69).

(8) Screw the armature adjusting screw (65) midway into the right-front armature assembly (67) and tighten it to the assembly with the hexagonal nut (66).

(9) Insert the entire assembly (67 with 65 and 66) into the right notch in the armature bracket (69).

(10) Attach the armature adjusting spring (68) between the armature adjusting screw (65) and the cotter pin (70).

(11) Mount the control magnet assembly (72) by its two spacers to the armature bracket (69) with the two machine screws (63) and plain washers (64).

(12) Mount the control magnet assembly (72) and armature bracket (69) to the front plate (51) with the four machine screws (61) and lockwashers (62).

c. Parts, Front and Back Plates (51) and (103).

(1) Knock the center staff bushing (52) back into its hole in the back plate (103).

(2) Knock the center staff bushing (48) back into its hole in the front plate (51).

(3) Insert the center staff assembly (47) through the center staff bushing (48) in the front plate (51).

(4) Place the center staff spacer (60) and the seconds reset cam assembly (59) on the center staff assembly (47). Do not tighten the setscrews (58) until later ((10) below).

(5) Replace the two identical friction springs (55 and 57) on the two studs on the control disk assembly (56) and place the control disk assembly on the center staff assembly (47). There should be absolutely no play between the loops of the springs and the studs on the control disk assembly (56). The loops should be snug (yet not bind) so that the spring arm pressures may equalize. It is also necessary that the straight portions of the springs be parallel and in the same vertical plane when assembled to the disk assembly.

(6) Spread the fingers of the friction spring (57) and set them into the groove in the seconds reset cam assembly (59). This positions the control disk assembly (56) to the seconds reset cam assembly (59).

(7) Place the center staff gear assembly (54) onto the center staff assembly (47).

(8) Spread apart the fingers of the friction spring (55) and set them into the groove in the center staff gear assembly (54) to the control disk assembly (56).

(9) Place the curved friction center staff washer (53) onto the center staff assembly (47). Push this washer up against the center staff gear assembly (54) and make sure all components are pushed up against the rear of the front plate (51).

(10) Insert a .0135-inch thick feeler gage between the center staff spacer (60)

and the seconds reset cam assembly (59), and tighten the two setscrews (58). When the feeler gage is removed, the curved friction center staff washer (53) will expand axially and this will cause the proper degree of preloading on the center staff assembly (47).

(11) Connect one lead from the control magnet assembly (72) to terminal 1 of the terminal board (85) and the other lead to the screw-type splice cap alongside the rotary electrical solenoid (21).

(12) Join the front and back plate assemblies by screwing the four machine screws (49) and lockwashers (50) through the front plate (51) to the four main pillars (104) on the back plate (103).

(13) Mount the inside magnet assembly (45) on the center staff assembly (47) and tighten the two setscrews (46).

(14) Mount the magnet cup assembly (44) on the center staff assembly (47) so that it incloses the inside magnet assembly (45) and fits between the two clutch shoes (67 and 71).

(15) Place the friction spring (43) on the stud of the totalizer gear assembly (42) as described in (5) above, and mount the gear assembly onto the shaft of the magnet cup assembly (44).

(16) Place the totalizing reset arm assembly (38) through the front plate (51) and place the reset spring (41), reset arm spacer (40), and seconds reset arm assembly (39) on it from the rear of the front plate, continue the arm assembly (38) through the back plate (103).

(17) Knock back the taper pin (36) that holds the seconds reset arm assembly (39) to the totalizing reset arm assembly (38).

(18) Connect one end of the reset spring (41) underneath the arm assembly (39) and the other end into the hole in the front plate (51).

(19) Mount the reset arm bushing (35) on the totalizing reset arm assembly (38) and tighten the setscrew (34).

(20) Knock back the taper pin (33) that holds the reset arm bushing (35) to the totalizing reset arm assembly (38).

(21) Set the reset actuating arm (32) into the reset arm bushing (35) and tighten the setscrew (31).

(22) Replace the plain washer (22) and cotter pin (23) on the shaft at the rear of the rotary electrical solenoid (21).

(23) Mount the rotary electrical solenoid (21) to the solenoid bracket (20) with the hexagonal nut (29) and lockwasher (30).

(24) Mount the terminal board (16) to the solenoid bracket (20) with the two machine screws (14) and lockwashers (15).

(25) Mount the rotary electrical solenoid (21), the solenoid bracket (20), and the terminal board (16) to the back plate (103) with the two machine screws (27) and lockwashers (28).

(26) Mount one end of the solenoid bracer (19) to the front plate (51) with the machine screw (24), the hexagonal nut (26), and lockwasher (25).

(27) Mount the other end of the solenoid bracer (19) to the rotary electrical solenoid (21) with the hexagonal nut (17) and split washer (18).

(28) Replace the two leads from the rotary electrical solenoid (21) to the terminal board (16).

d. Parts, Front of Front Plate (51).

(1) Mount the pinion assembly (13) to the front plate with the intermediate gear bracket (12); use the two machine screws (10) and lockwashers (11).

(2) Place the totalizer reset cam assembly (9) through the dial (8) from the rear, and press-fit the totalizer hand assembly (6) onto it from the front of the dial.

(3) Place the cam reset assembly (9), the dial (8), and the totalizer hand assembly (6) onto the center staff assembly (47).

(4) Position the cam reset assembly to the totalizer gear assembly (42) by spreading the fingers of the friction spring (43) and placing the fingers in the groove of the cam reset assembly (9).

e. Red and Black Pointers.

(1) Mount the split seconds (red) hand (5) to the outside magnet cup assembly (44) with the split seconds retaining nut (4).

(2) Mount the seconds (black) hand (3) to the center staff assembly (47) with the machine screw (1) and lockwasher (2).

(3) Mount the dial (8) to the two pillars on the front plate (51) with the two machine screws (7). Note that the dial must be concentrically mounted relative to hand rotation and with the quarter points on the center lines of the movement. Rotate either the red or black hand to the quarter points and compare the distance between the tip of the hand and the scale circle. This provides an easy and accurate method of checking concentricity. The seconds hand (3) must be centered on the top graduation of the dial. The split seconds hand (5) centers on the seconds hand (3). The totalizer hand should have a slight amount of play, not exceeding the width of the tip of the hand. This permits emphasis on resetting the faster seconds hand (3) to the zero position.

f. Mounting Timer S6 to Front Panel.

(1) Mount the timer S6 to the front panel with the four No. 6–32 by ⅜-inch long mounting screws as shown in figure 16.

(2) Reconnect the tagged leads to the lower four terminals of terminal board TB1 and to terminals 8 and 9 of terminal board TB2 (fig. 7).

47. Checking and Adjusting Timer S6 (fig. 17)

a. Clutch Shoe Alinement and Clearance. The clutch shoes are the U-shaped pieces welded to the upper ends of pieces (67), (71), (94), and (98) in figure 17. The clutch shoes must center on the face of the control disk assembly (56) within a maximum tolerance of $\frac{1}{64}$ inch. In addition, there should be a clearance between the top points of the clutch shoes and the control disk assembly of .015 inch to .020 inch. All four points of the shoes should contact the control disk assembly in the de-energized position. The points of contact must be evenly adjusted to prevent a kick to the hands from clutch operation. Note that these points are adjusted in a special fixture by the manufacturer. If it is necessary to readjust these points, bend the armature assemblies (94 and 98) slightly, and adjust by eye.

b. Drive Spring Tension. The drive friction spring (57) tension should be set for a torque between .640-inch ounce to .683-inch ounce. To check this, proceed as follows:

(1) Energize both control magnet assemblies (72 and 99).

(2) Hang a 1-ounce weight on the split seconds hand (5) from .604 inch to .683 inch from the center of the center staff shaft.

(3) The hand should move only when the weight is between .640 inch and .683 inch from the center of the shaft.

(4) If there is insufficient torque, place one screwdriver on each side of the neck of the friction spring (57) and press together. If there is too much torque, pry up one end of the friction spring (to decrease the torque). Be sure to recheck as instructed in (1) through (4) above.

c. Seconds Reset Spring Tension. The seconds reset friction spring (55) tension should be set for a torque between .645-inch ounce to .713-inch ounce. This spring tension must be greater than the drive spring tension (*b*(2) above) so that when the magnet is energized, stopping the seconds hand (3) will cause slippage to occur at the drive friction spring (57) rather than at the reset friction spring (55). Check this torque as follows:

(1) Energize the front control magnet assembly (72), but not the rear control magnet assembly (99).

(2) Hang a 1-ounce weight on the seconds hand (3) from .645 inch to .713 inch from the center of the center staff shaft.

(3) The hand should move only when the weight is between .645 inch and .713 inch from the center of the shaft.

(4) If the torque is incorrect, adjust the friction spring (55) as instructed in *b* (4) above.

d. Totalizer Hand Friction Spring Tension. The totalizer hand friction spring (43) should be set for a torque between .187-inch ounce and .218-inch ounce. To check this, proceed as follows:

(1) De-energize both control magnet assemblies (72 and 99).

(2) Hang a ¼-ounce weight on the totalizer hand assembly (6) from ¾ inch to ⅞ inch from the center of the shaft while the hand is in the horizontal plane.

(3) The hand should move only when the weight is between ¾ inch and ⅞ inch from the center of the shaft.

(4) If the torque is incorrect, adjust the friction spring (43) as described in *b* (4) above.

e. Jump Test. Energize the control magnet assemblies (72 and 99), and then de-energize them. When the magnet is de-energized, the hand should stop. If the hand continues rotating, recheck the adjustment (*a–d* above).

f. Debuzzing Control Magnets. Buzzing is ac hum caused by armature vibration at 80 percent (or more) of its rated voltage. Debuzzing is the adjustment of the armature with respect to the control magnet assembly (72 or 99) so that when the 117-volts, 60-cycles per second (cps) is applied to the magnet, the armature pulls up the magnet ends without vibration or noise. This is accomplished by bending the armature. Be sure that this bending does not disturb the alinement and adjustment of the brake-shoe end of the armature (*a* above). If it is necessary to bend the armature, make sure the armature adjusting screws (65 and 92) are in their midposition, and proceed as illustrated in figure 18.

g. Calibration. If the motor is running synchronously, no other calibration of the timer is required. Check to see that the motor is running synchronously by running the timer for several hours and checking it against a standard clock. Operate the timer for 20 consecutive 250-millisecond intervals. The maximum error for any interval should not exceed 10 milliseconds, and the total error should not exceed .50 second. If this error is exceeded, replace the synchronous motor (78, fig. 17).

48. Disassembly of Timer S5 (fig. 19)

To disassemble timer S5, proceed as follows: Refer to figure 20. Remove and tag the *lower* leads from all seven terminals of terminal board TB3 and from terminals 8 and 9 of terminal board TB4. This disconnects the timer from all circuits of the signal set. Remove the four No. 6–32 by ⅜-inch mounting screws (fig. 16) that mount the 1/100 timer (S5) to the front panel and remove the complete timer assembly as described in paragraph 44.

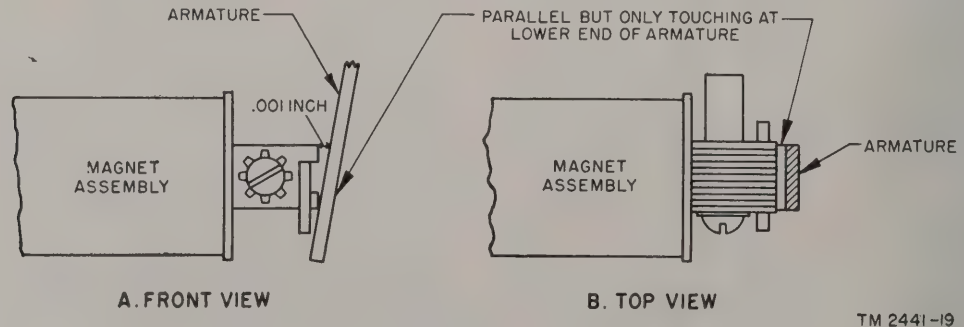
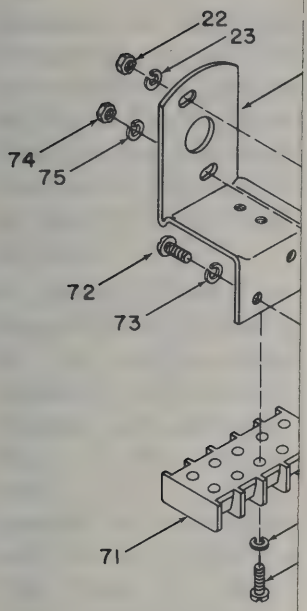


Figure 18. Bending armatures of control magnet.


22
23
74
75
72
73
71

(1) Energize the front control magnet assembly (72), but not the rear control magnet assembly (99).

(2) Hang a 1-ounce weight on the seconds hand (3) from .645 inch to .713 inch from the center of the center staff shaft.

(3) The hand should move only when the weight is between .645 inch and .713 inch from the center of the shaft.

(4) If the torque is incorrect, adjust the friction spring (55) as instructed in *b* (4) above.

d. Totalizer Hand Friction Spring Tension. The totalizer hand friction spring (43) should be set for a torque between .187-inch ounce and .218-inch ounce. To check this, proceed as follows:

(1) De-energize both control magnet assemblies (72 and 99).

(2) Hang a ¼-ounce weight on the totalizer hand assembly (6) from ¾ inch to ⅞ inch from the center of the shaft while the hand is in the horizontal plane.

(3) The hand should move only when the weight is between ¾ inch and ⅞ inch from the center of the shaft.

(4) If the torque is incorrect, adjust the friction spring (43) as described in *b* (4) above.

e. Jump Test. Energize the control magnet assemblies (72 and 99), and then de-energize them. When the magnet is de-energized, the hand should stop. If the hand continues rotating, recheck the adjustment (*a–d* above).

f. Debuzzing Control Magnets. Buzzing is ac hum caused by armature vibration at 80 percent (or more) of its rated voltage. Debuzzing is the adjustment of the armature with respect to the control magnet assembly (72 or 99) so that when the 117-volts, 60-cycles per second (cps) is applied to the magnet, the armature pulls up the magnet ends without vibration or noise. This is accomplished by bending the armature. Be sure that this bending does not disturb the alinement and adjustment of the brake-shoe end of the armature (*a* above). If it is necessary to bend the armature, make sure the armature adjusting screws (65 and 92) are in their midposition, and proceed as illustrated in figure 18.

g. Calibration. If the motor is running synchronously, no other calibration of the timer is required. Check to see that the motor is running synchronously by running the timer for several hours and checking it against a standard clock. Operate the timer for 20 consecutive 250-millisecond intervals. The maximum error for any interval should not exceed 10 milliseconds, and the total error should not exceed .50 second. If this error is exceeded, replace the synchronous motor (78, fig. 17).

48. Disassembly of Timer S5 (fig. 19)

To disassemble timer S5, proceed as follows: Refer to figure 20. Remove and tag the *lower* leads from all seven terminals of terminal board TB3 and from terminals 8 and 9 of terminal board TB4. This disconnects the timer from all circuits of the signal set. Remove the four No. 6–32 by ⅜-inch mounting screws (fig. 16) that mount the 1/100 timer (S5) to the front panel and remove the complete timer assembly as described in paragraph 44.

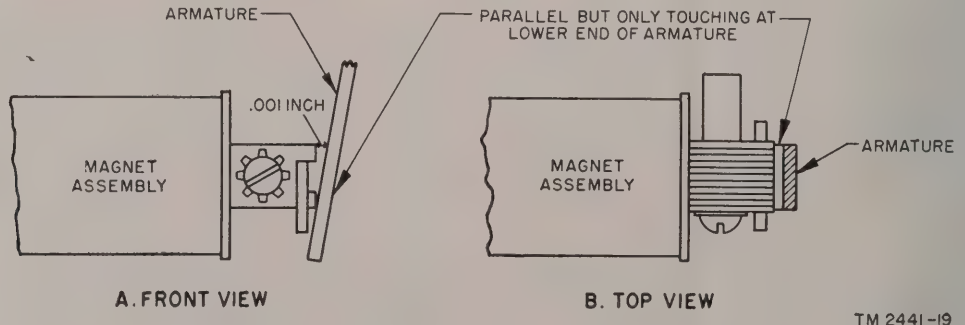
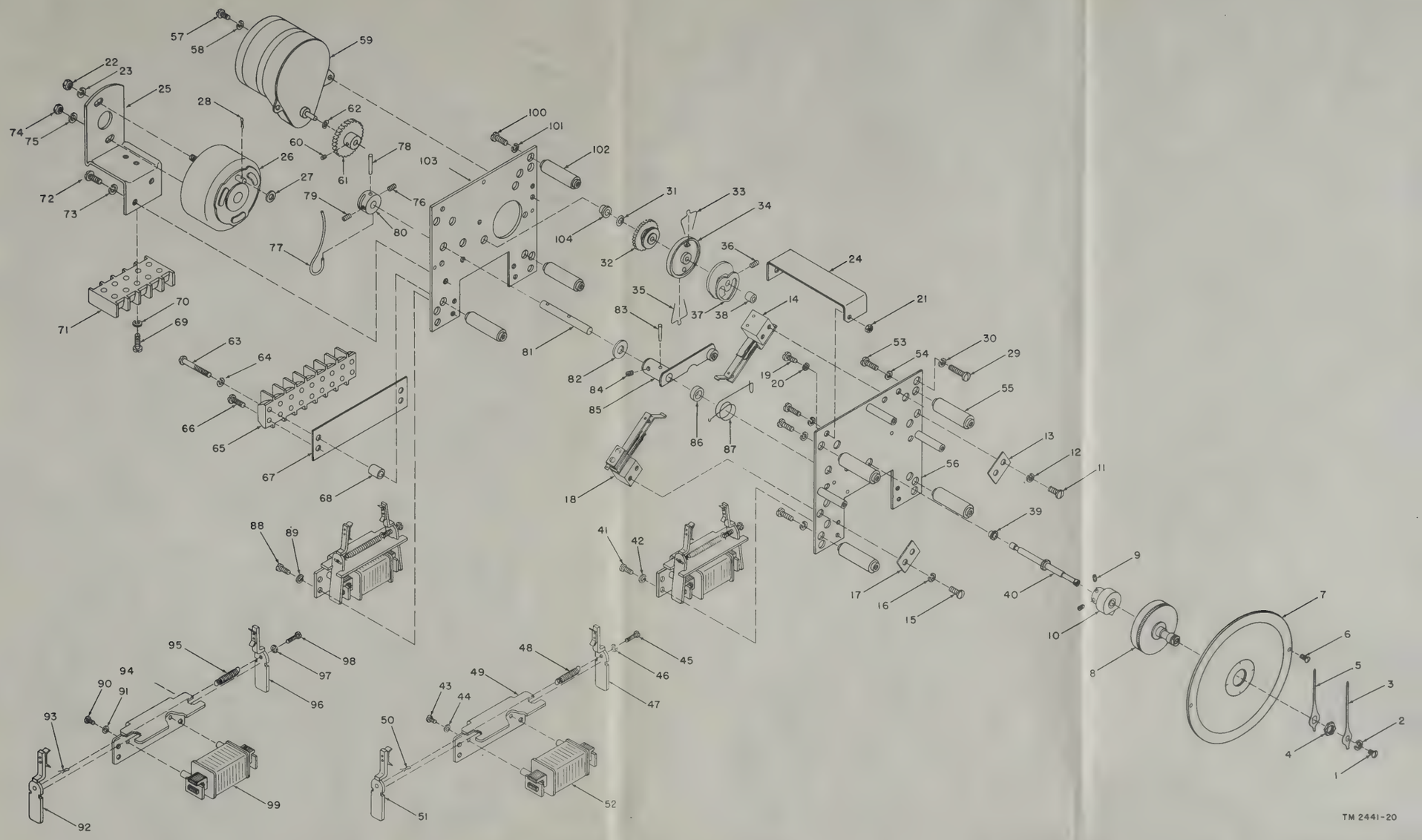


Figure 18. Bending armatures of control magnet.



1 Machine screw; roundhead, #2–56 by 1/8 inch long.
2 Lockwasher; for #2 screw.
3 Seconds hand (O 21).
4 Hexagonal nut; #10–48.
5 Split seconds hand (O 22).
6 Machine screw; binding head, #2–56 by 1/8 inch long.
7 Dial: aluminum, 3.7 inch outside diameter, .020 inch thick, marked with 100 divisions.
8 Magnet cup assembly: 1.25 inch outside diameter, .963 inch long.
9 Setscrew; Allen head, #4–40 by 1/8 inch long.
10 Magnet assembly (inside): 5/8 inch outside diameter, .452 inch long.
11 Machine screw; binding head, #6–32 by 1/4 inch long.
12 Lockwasher; for #8 screw.
13 Washer plate (contact block): 3/8 inch wide, 11/16 inch long.
14 Contact block assembly (E1).
15 Machine screw; binding head, #6–32 by 1/4 inch long.
16 Lockwasher; for #8 screw.
17 Washer plate (contact block): 3/8 inch wide, 11/16 inch long.
18 Contact block assembly (E2).
19 Machine screw; roundhead, #6–32 by 3/8 inch long.
20 Lockwasher; for #6 screw.
21 Hexagonal nut; #6–32.
22 Hexagonal nut; steel, #8–32.
23 Lockwasher; steel, for #8 screw.
24 Solenoid bracer; 2.745 inch long, 3/4 inch wide, .56 inch high.
25 Solenoid bracket; steel, 3 inch long, 1 1/4 inch wide, .075 inch thick.
26 Rotary solenoid (L1).
27 Plain washer; 3/8 outside diameter, .147 inside diameter, 1/32 inch thick.
28 Cotter pin; 1/32 inch diameter by 3/4 inch long.
29 Machine screw; roundhead, #6–32 by 1/4 inch long.
30 Lockwashers; for #6 screw.
31 Curved washer (O 24).
32 Gear assembly (center staff) (O 12).
33 Friction spring (O 16).
34 Control disk assembly (O 25).
35 Friction spring (O 16).
36 Setscrew; Allen head, #4–40 by 1/8 inch long.
37 Cam assembly (impulse) (O 26).
38 Center staff spacer; .141 inch long.
39 Center staff bushing; oilite bronze, .238 inch outside diameter, .1885 inch inside diameter, 1/8 inch long.
40 Center staff assembly; 1/16 inch outside diameter, 2.406 inch long.
41 Machine screw; fillister head, #4–40 by 1/4 inch long.
42 Lockwasher; for #4 screw.
43 Machine screw; roundhead, 1 #4–40 by 1/16 inch long.
44 Plain washer; 1/4 inch outside diameter, 1/8 inch inside diameter, .020 inch thick.
45 Armature adjusting screw; roundhead, #4–48 by 5/8 inch long, #65 hole in one end.
46 Hexagonal nut; #4–48.
47 Armature assembly (left front): 1 1/8 inch long, 3/8 inch wide.
48 Armature adjusting spring (O 20).
49 Armature bracket; 2 1/2 inch long, 3/4 inch wide, 3/8 inch high.
50 Cotter pin; 1/16 inch diameter by 1/2 inch long.
51 Armature assembly (right front); 1 1/8 inch long, 3/8 inch wide.
52 Control magnet assembly (E3).
53 Machine screw; roundhead, #6–32 by 1/4 inch long.
54 Lockwasher; for #6 screw.
55 Movement mounting pillar; 1/16 inch outside diameter, 1.296 inch long overall, taped #6–32 by 1/16 inch long both ends.
56 Front plate; 3 3/16 inch wide, 3 3/4 inch long, 1/16 inch thick.
57 Machine screw; roundhead, #4–40 by 1/16 inch long.
58 Lockwasher; for #4 screw.
59 Motor (B2).
60 Setscrew; Allen head, #4–40 by 1/8 inch long.
61 Motor gear assembly: .809 inch outside diameter, .1255 inch inside diameter, .312 inch long.
62 Curved washer; .312 inch outside diameter, .132 inch inside diameter, .004 inch thick.
63 Machine screw; roundhead, #6–32 by 5/8 inch long.
64 Lockwasher; for #6 screw.
65 Terminal board (TB1).
66 Machine screw; roundhead, #6–32 by 3/8 inch long.
67 Terminal plate board; 3 3/8 inch long, 7/8 inch wide, .025 inch thick.
68 Terminal board spacer; 1/4 inch outside diameter, .1695 inch inside diameter, 5/32 inch long.
69 Machine screw; roundhead, #6–32 by 3/8 inch long.
70 Lockwasher; for #6 screw.
71 Terminal board (TB2).
72 Machine screw; roundhead, #8–32 by 1/4 inch long.
73 Lockwasher; for #8 screw.
74 Hexagonal nut; #8–32.
75 Lockwasher; for #8 screw.
76 Setscrew; Allen head, #4–40 by 1/8 inch long.
77 Reset actuating arm: 1/16 inch outside diameter, 1 5/8 inch long overall; part of O 19.
78 Taper pin; #5/0 by 1/2 inch long.
79 Setscrew; Allen head, #4–40 by 1/8 inch long; part of O 19.
80 Reset arm bushing: 1/16 inch wide, 1/16 inch high, 1/4 inch deep; part of O 19.
81 Seconds reset staff; .1875 inch outside diameter, 1 1/2 inch long.
82 Reset arm spacer.
83 Taper pin; #5/0 by 1/2 inch long.
84 Setscrew; Allen head, #6–32 by 1/8 inch long.
85 Arm assembly (seconds reset); .946 inch wide, 2 inch long.
86 Reset arm spacer; 1/16 inch outside diameter, .196 inch inside diameter, .122 inch long.
87 Reset spring (O 17).
88 Machine screw; fillister head, #4–40 by 1/4 inch long.
89 Lockwasher; for #4 screw.
90 Machine screw; roundhead, #4–40 by 1/16 inch long.
91 Plain washer; 1/4 inch outside diameter, 1/8 inch inside diameter, .020 inch thick.
92 Armature assembly (back left); 1 5/32 inch long, .460 inch wide.
93 Cotter pin; 1/16 inch diameter by 1/2 inch long.
94 Armature bracket; 2 1/2 inch long, 3/32 inch wide, 3/32 inch high.
95 Armature adjusting spring (O 18).
96 Armature assembly (back right); 1 3/32 inch long, .460 inch wide.
97 Hexagonal nut; #4–48.
98 Armature adjusting screw; roundhead, #4–48 by 5/8 inch long, #65 hole in one end.
99 Control magnet assembly (E4).
100 Machine screw; roundhead, #6–32 by 1/4 inch long.
101 Lockwasher; for #6 screw.
102 main pillar; 1/16 inch outside diameter, .113 inch inside diameter, 1.167 inch long.
103 Back plate; 3 3/4 inch long, 3 3/4 inch wide, 1/16 inch thick.
104 Center staff bushing; oilite bronze, .238 inch outside diameter, .1885 inch inside diameter, 1/8 inch long.

Figure 19. Timer S5, 1/100 (two-hand), exploded view.

a. Red and Black Hands.

(1) Unscrew the one machine screw (1, fig. 19) and lockwasher (2) from the shaft of the center staff assembly (40) and pull off the black seconds hand (3).

(2) Unscrew the split seconds retaining hexagonal nut (4) from the shaft of the magnet cup assembly (8) and pull off the red split seconds hand (5).

(3) Unscrew the two machine screws (6) that mount the dial (7) to the pillars on the front plate (56) and remove the dial.

b. Parts, Front of Front Plate (56).

(1) Spread the left-front armature assembly (51) and the right-front armature assembly (47) apart and pull out the magnet cup assembly (8) from the shaft of the center staff assembly (40).

(2) Loosen the two set-screws (9) and pull off the inside magnet assembly (10) from the shaft of the center staff assembly (40).

(3) Unscrew the two machine screws (11) and lockwashers (12) from the contact block assembly (14) and remove the contact block washer plate (13). The contact block assembly (14) will dangle by two leads; tag and then unsolder one lead from terminal 6 of the terminal board (65) and the other lead from the other contact block assembly (18).

c. Parts, Front and Back Plates (56) and (103).

(1) Unscrew the two machine screws (15) and lockwashers (16) from the contact block assembly (18) and remove the contact block washer plate (17). The contact block assembly will dangle by two leads; tag and then unsolder one lead from terminal 5 of the terminal board (65) and the other lead from terminal 7 of the terminal board (65).

(2) Unscrew the machine screw (19) and lockwasher (20) from the hexagonal nut (21) that mounts the solenoid bracer (24) to the front plate (56).

(3) Remove the hexagonal nut (22) lockwasher (23) that mounts the rotary solenoid (26) through the solenoid bracer (24) to the front plate (56) and remove the solenoid bracer.

(4) Remove the cotter pin (28) and plain washer (27) from the rear of the rotary solenoid (26).

(5) Unhook the free end of the reset spring (87) from the reset arm assembly (85) and let the spring dangle from the rear of the front plate (56).

(6) Unscrew the four machine screws (29) and lockwashers (30) that mount the front plate (56) to the pillars on the back plate (103) and separate the front and back plate assemblies as limited by the two interconnecting leads. Remove and tag the one lead from the control magnet assembly (52) to terminal 1 of the terminal board (65) and the other lead from the control magnet assembly (52) to the screw-type splice cap alongside the rotary solenoid.

(7) Pull off the curved washer (31) from the shaft of the center staff assembly (40).

(8) Open the fingers of the friction spring (35) that holds the center staff gear assembly (32) to the control disk assembly (34) and pull off the center staff gear assembly (32).

(9) Open the fingers of the friction spring (33) that holds the control disk assembly (34) to the impulse can assembly (37) and remove the control disk.

(10) Remove and tag the two similar friction springs (33 and 35) from the control disk assembly (34). These springs have different tensions, therefore, identify them clearly.

(11) Loosen the two setscrews (36) in the impulse cam assembly (37) and pull off the impulse cam assembly and the center staff spacer (38) from the shaft of the center staff assembly (40) and pull the center staff assembly out from its center staff bushing (39) in the front plate (56).

(12) Knock out the center staff bushing (39) from its hole in the front plate (56).

d. Control Magnet Assembly (52) and Motor (59).

(1) Unscrew the four machine screws (41) and lockwashers (42) that hold the armature bracket (49) and control magnet assembly (52) to the front plate (56).

(2) Unscrew the two machine screws (43) and plain washers (44) that mount the control magnet assembly (52) by two spacers to the armature bracket (49), and remove the assembly.

Note. Do not disassemble the control magnet assembly any further since the magnet core is ground after assembly. Replace the magnet assembly as a unit, if necessary.

(3) Unhook the armature adjusting spring (48) from the cotter pin (50) in the left-front armature assembly (51) and from the hole in the armature adjusting screw (45).

(4) Pull out the armature adjusting screw (45), the hexagonal nut (46), and the right-front armature assembly (47) together from the notch in the armature bracket (49).

(5) Loosen the hexagonal nut (46) and unscrew the armature adjusting screw (45) from the right-front armature assembly (47).

(6) Pull out the cotter pin (50) and the left-front armature assembly (51) together from the notch in the armature bracket (49), and remove the cotter pin (50) from the armature assembly (51).

(7) Unscrew the four screws (53) and lockwashers (54) mounting the movement mounting pillars (55) to the front of the front plate (56).

(8) Unscrew the two machine screws (57) and lockwashers (58) that mount the motor (59) to the back plate (103) and let the motor dangle by its two leads. Remove one lead from terminal 3 of the terminal board (65) and the other lead from the screw-type splice cap alongside the motor (59).

(9) Loosen the two setscrews (60) from the motor gear assembly (61) and pull off the motor gear and the curved washers (62) from the shaft of the motor (59).

(10) Unscrew the two machine screws (63) and lockwashers (64) that mount the terminal board (65) and the terminal plate board (67) through the terminal board spacers (68) to the rear of the back plate (103).

(11) Unscrew the two machine screws (66) that hold the terminal board (65) to the terminal plate board (67) and separate these two boards.

(12) Unscrew the two machine screws (69) and lockwashers (70) that mount the terminal board (71) to the solenoid bracket (25) and separate the terminal board (71) from the solenoid bracket (25).

(13) Unscrew the two machine screws (72) and lockwashers (73) that mount the solenoid bracket (25) to the rear of the back plate (103).

(14) Remove the hexagonal nut (74) and lockwasher (75) that hold the solenoid bracket (25) to the rotary solenoid (26) and separate the rotary solenoid (26) from the solenoid bracket (25).

(15) Loosen the setscrew (76) and pull out the reset actuating arm (77) from the reset arm bushing (80).

(16) Knock out the taper pin (78) from the reset arm bushing (80) with a drift pin. Note the taper when knocking out the pin.

(17) Loosen the setscrew (79) and pull the reset arm bushing (80) off the seconds reset staff (81).

(18) Knock out the taper pin (83) from the seconds reset arm assembly (85) with a drift pin. Note the taper when knocking out the pin.

(19) Loosen the two setscrews (84) and pull out the seconds reset staff (81), the reset arm spacer (82), and the

reset arm spacer (86) from the seconds reset arm assembly (85).

(20) Remove the reset spring (87) from the hole in the rear of the front plate (56).

e. Control Magnet Assembly (99).

(1) Unscrew the four machine screws (88) and lockwashers (89) that hold the armature bracket (94) to the back plate (103).

(2) Unscrew the two machine screws (90) and plain washers (91) that mount the control magnet assembly (99) by its two spacers to the armature bracket (94) and remove the magnet assembly.

Note. Do not disassemble the control magnet assembly any further since the magnet core is ground after assembly. If necessary, replace it as a unit.

(3) Unhook the armature adjusting spring (95) from the cotter pin (93) in the left-back armature assembly (92) and from the hole in the end of the armature adjusting screw (98).

(4) Pull out the left-back armature assembly (92) and the cotter pin (93) together from the notch in the armature bracket (94) and remove the cotter pin from the armature assembly.

(5) Pull out the right-back armature assembly (96), the hexagonal nut (97) and the armature adjusting screw (98) together from the notch in the armature bracket (94).

(6) Loosen the hexagonal nut (97) and unscrew the armature adjusting screw (98) from the right-back armature assembly (96).

(7) Remove and tag the leads from the control magnet assembly (99) to terminal 2 of the terminal board (65) and to the screw-type splice cap alongside the motor.

(8) Unscrew the four machine screws (100) and lockwashers (101) that mount the main pillars (102) to the front of the back plate (103).

(9) Knock out the center staff bushing (104) from its hole in the back plate (103).

49. Reassembly of Timer S5

(fig. 19)

To reassemble timer S5, proceed as follows:

a. Control Magnet Assembly (99).

(1) Knock the center staff bushing (104) back into its hole in the back plate (103).

(2) Mount the four main pillars (102) to the front of the back plate (103) with the four machine screws (100) and lockwashers (101).

(3) Reconnect the one lead from the control magnet assembly (99) to terminal 2 of the terminal board (65) and the other lead to the screw-type splice cap.

(4) Screw the armature adjusting screw (98) midway into the right-rear armature assembly (96) and tighten it to the assembly with the hexagonal nut (97).

(5) Insert the entire assembly (96 with 97 and 98) into the right notch in the armature bracket (94).

(6) Place the cotter pin (93) in the left-rear armature assembly (92) and insert the asembly (and cotter pin) into the left notch in the armature bracket (94).

(7) Attach the armature adjusting spring (95) between the armature adjusting screw (98) and the cotter pin (93).

(8) Mount the control magnet assembly (99) by its two spacers to the armature bracket (94) with the two machine screws (90) and plain washers (91).

(9) Mount the control magnet assembly (99) and armature bracket (94) to the back plate (103) with the four machine screws (88) and lockwashers (89).

b. Control Magnet Assembly (52) and Motor (59).

(1) Insert the seconds reset staff (81) through the back plate (103) and mount the reset arm spacer (82), the seconds reset arm assembly (85), the reset arm spacer (86), and the reset spring (87) on it.

(2) Knock the tapered pin (83) back

through the seconds reset arm assembly (85) and into the seconds reset staff (81).

(3) Tighten the two setscrews (84).

(4) Hook one end of the reset spring (87) under the seconds reset arm assembly (85) and the other end into the hole in the front plate (56).

(5) Mount the reset arm bushing (80) onto the seconds reset staff (81).

(6) Knock the taper pin (78) back through the reset arm bushing (80) into the seconds reset staff (81).

(7) Tighten the setscrew (79) in the reset arm bushing (80).

(8) Insert the reset actuating arm (77) back into the reset arm bushing (80).

(9) Tighten the setscrew (76) in the reset arm bushing (80).

(10) Mount the rotary solenoid (26) to the solenoid bracket (25) with the hexagonal nut (74) and lockwasher (75).

(11) Mount the rotary solenoid (26) and the solenoid bracket (25) to the rear of the back plate (103) with the two machine screws (72) and lockwashers (73).

(12) Mount the terminal board (71) to the solenoid bracket (25) with the two machine screws (69) and lockwashers (70).

(13) Attach the terminal board (65) to the terminal plate board (67) with the two machine screws (66).

(14) Mount the terminal board (65), the terminal plate board (76) and the two terminal board spacers (68) to the rear of the back plate (103) with the two machine screws (63) and lockwashers (64).

(15) Slip the curved washers (62) and the motor gear assembly (61) onto the shaft of the motor (59) and then tighten the two setscrews (60) in the motor gear.

(16) Reconnect one lead from the motor (59) to terminal 3 of the terminal board (65) and the other lead to the screw-type splice cap.

(17) Mount the motor (59) to the back plate (103) with the two machine screws (57) and lockwashers (58).

(18) Mount the four movement mounting pillars (55) to the front of the front plate (56) with the four machine screws (53) and lockwashers (54).

(19) Replace the cotter pin (50) in the left-front armature assembly (51) and insert the assembly (and cotter pin) into the left notch in the armature bracket (49).

(20) Screw the armature adjusting screw (45) midway into the right-front armature assembly (47) and tighten it to the assembly with the hexagonal nut (46).

(21) Insert the entire assembly (47 with 45 and 46) into the right notch in the armature bracket (49).

(22) Attach the armature adjusting spring (48) between the armature adjusting screw (45) and the cotter pin (50).

(23) Mount the control magnet assembly (52) by its two spacers to the armature bracket (49) with the two machine screws (43) and plain washers (44).

c. Parts, Front and Back Plates (56 and 103).

(1) Mount the control magnet assembly (52) and the armature bracket (49) to the front plate (56) with the four machine screws (41) and lockwashers (42).

(2) Knock the center staff bushing (39) back into its hole in the front plate (56).

(3) Insert the center staff assembly (40) through the oilite center staff bushing (39) in the front plate (56).

(4) Mount the center staff spacer (38) and the impulse cam assembly (37) onto the center staff assembly (40). Do not tighten the setscrews (36) in the impulse cam assembly until later (*11* below).

(5) Replace the two identical looking friction springs (33 and 35) on the two studs of the control disk assembly (34); be careful to replace the correct spring on the correct stud (as previously tagged). There should be ab-

solutely no play between the loops of the springs and the studs on the control disk assembly (34). The loops should be snug (yet not bind) so that the spring arm pressures can equalize. It is also necessary that the straight portions of the springs be parallel and in the same vertical plane when assembled to the disk.

(6) Place the control disk assembly (34) on the center staff assembly (40).

(7) Spread apart the fingers of the friction spring (33) and set them into the groove in the impulse cam assembly (37). This positions the control disk assembly (34) to the impulse cam assembly (37).

(8) Place the center staff gear assembly (32) on the center staff assembly (40).

(9) Spread apart the fingers of the friction spring (35) and set them into the groove in the center staff gear assembly (32). This positions the center staff gear to the control disk assembly (34).

(10) Place the curved washer (31) on the center staff assembly (40). Push the washer up against the center staff gear assembly (32); make sure that all the components are pushed up against the rear of the front plate (56).

(11) Insert a .0135-inch thick feeler gage between the center staff spacer (38) and the impulse cam assembly (37), and tighten the two setscrews (36) in the impulse cam assembly. When the feeler gage is removed, the curved washer (31) will expand axially, causing the proper degree of preloading on the center staff assembly (40).

(12) Reconnect one lead from the control magnet assembly (52) to terminal 1 of the terminal board (65) and the other lead from the control magnet to the screw-type splice cap alongside the rotary solenoid (26).

(13) Reassemble the front plate (56) and back plate (103) assemblies by mounting the front plate to the main pillars (102) onto the rear plate with the four machine screws (29) and lockwashers (30).

(14) Replace the plain washer (27) and cotter pin (28) on the shaft at the rear of the rotary solenoid (26).

(15) Mount the rotary solenoid (26) through one end of the solenoid bracer (24) to the front plate (56) with the hexagonal nut (22) and lockwasher (23).

(16) Mount the other end of the solenoid bracer (24) to the front plate (56) with the one machine screw (19) and lockwasher (20).

(17) Resolder one lead from the contact block assembly (18) to terminal 5 of the terminal board (65) and the other lead to terminal 7 of the terminal board (65).

(18) Mount the contact block assembly (18) to the front plate (56) with the contact block washer plate (17) and the two machine screws (15) and lockwashers (16). The end of the contact block assembly should rest on the impulse cam assembly (37).

d. Parts, Front of Front Plate (56).

(1) Resolder one lead from the contact block assembly (14) to terminal 6 of the terminal board (65) and the other lead to the other contact block assembly (18).

(2) Mount the contact block assembly (14) to the front plate (56) with the contact block washer plate (13) and the two machine screws (11) and lockwashers (12). The end of the contact block assembly should rest on the impulse cam assembly (37). Note that this contact block assembly (14) mounts oppositely to the other contact block assembly (18) (*c*18 above).

(3) Mount the inside magnet assembly (10) on the center staff assembly (40) and tighten its two setscrews (9).

(4) Spread the right-front armature assembly (51) brake-shoes and the left-front armature assembly (47) brake-shoes apart, and mount the magnet

cup assembly (8) on the center staff assembly (40) around the inside magnet assembly (10).

(5) Slide the dial (7) on the shaft of the magnet cup assembly (8) and mount it to the two pillars on the front plate (56) with the two machine screws (6).

e. Red and Black Hands.

(1) Mount the split seconds hand (5) to the shaft of the magnet cup assembly (8) with the hexagonal nut (4).

(2) Mount the seconds hand (3) to the shaft of the center staff assembly (40) with the one machine screw (1) and lockwasher (2).

(3) The dial must be concentrically mounted relative to hand rotation and with the quarter points on the center lines of the movement. Rotate either the red or black hand to the quarter points and compare the distance between the tip of the hand and the scale circle. This provides an easy and accurate method of checking concentricity. If there is no concentricity, loosen the dial mounting screws (6) and shift the dial (7) accordingly. After being reset, the black seconds hand (3) must be centered on the top graduation of the dial. The red split seconds hand must clear center on the seconds hand (5).

f. Mounting Timer S5 to Front Panel.

(1) Mount the 1/100 timer (S5) to the front panel with the four No. 6–32 by $\frac{3}{8}$-inch long mounting screws as shown in figure 16.

(2) Reconnect the tagged leads to the lower seven terminals of TB3 and to terminals 8 and 9 of TB4 (fig. 20).

50. Checking and Adjusting Timer S5 (fig. 19)

a. Clutch Shoe Alinement and Clearance. The clutch shoes in this timer are the U-shaped parts welded to the upper ends of parts (47, 51, 92, and 96) in figure 19. The clutch shoes must center on the face of the control disk assembly (34) as described similarly for the three-hand timer in paragraph 47*a*. If it is necessary to readjust the points, bend the armatures (92 and 96) slightly and adjust by eye.

b. Drive Spring Tension. The drive friction spring (33) tension should be set for the proper tension similarly to that described for the three-hand timer in paragraph 47*b*. The applicable control magnet assemblies are parts (52 and 99) in figure 19.

c. Seconds Reset Spring Tension. The seconds reset friction spring (35) should be set for the proper tension similarly to that described for the three-hand timer in paragraph 47*c*. The applicable control magnet assemblies are parts (52) and (99) in figure 19.

d. Jump Test. Energize the control magnet assemblies (52 and 99) ; then de-energize them. When the magnet is de-energized, the hand should stop rotating. If the hand continues to rotate, recheck the adjustments in *a* through *c* above.

e. Debuzzing Control Magnets. Check the control magnet assemblies (52 and 99) for buzzing similarly to the procedure described for the three-hand timer in paragraph 47*f*. The applicable armature adjusting screws are parts (45 and 98) in figure 19.

f. Calibration. Check the calibration of the timer similarly to that described for the three-hand timer in paragraph 47*g*. The applicable synchronous motor is part (59) in figure 19.

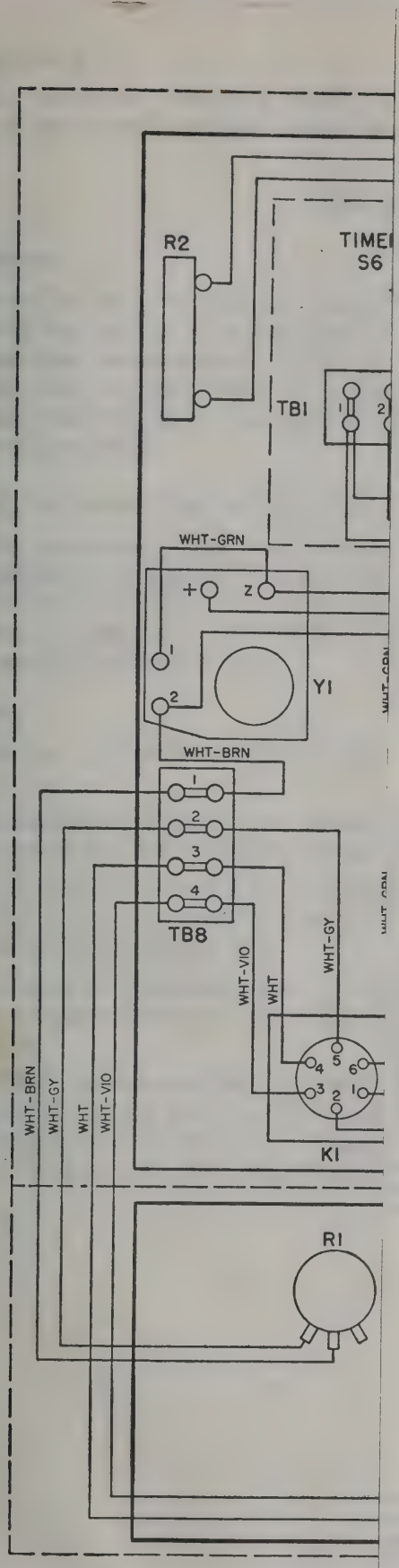
g. Contact Points. Check the proper operation of the contact block assemblies (14 and 18) as follows:

(1) Connect a light (with source voltage) in series across terminals 5 and 7 of terminal board TB3 (fig. 20).

(2) Move the hands manually, and visually check the operation of the contacts as shown by the light.

(3) The light should light seven $\frac{1}{100}$ minutes before the 50 mark and should go off at the 50 mark; and, it should go on again seven $\frac{1}{100}$ minutes before the 100 mark and go off at the 100 mark.

(4) If this time interval is incorrect, replace either (or both) contact block assembly (14 or 18, fig. 18), as necessary.


R2
TIME
S6
TB1
WHT-GRN
+
Z
1
2
Y1
WHT-BRN
1
2
3
4
TB8
WHT-VIO
WHT
WHT-GY
WHT-BRN
WHT-GY
WHT
WHT-VIO
4
5
6
3
2
1
K1
R1

cup assembly (8) on the center staff assembly (40) around the inside magnet assembly (10).

(5) Slide the dial (7) on the shaft of the magnet cup assembly (8) and mount it to the two pillars on the front plate (56) with the two machine screws (6).

e. Red and Black Hands.

(1) Mount the split seconds hand (5) to the shaft of the magnet cup assembly (8) with the hexagonal nut (4).

(2) Mount the seconds hand (3) to the shaft of the center staff assembly (40) with the one machine screw (1) and lockwasher (2).

(3) The dial must be concentrically mounted relative to hand rotation and with the quarter points on the center lines of the movement. Rotate either the red or black hand to the quarter points and compare the distance between the tip of the hand and the scale circle. This provides an easy and accurate method of checking concentricity. If there is no concentricity, loosen the dial mounting screws (6) and shift the dial (7) accordingly. After being reset, the black seconds hand (3) must be centered on the top graduation of the dial. The red split seconds hand must clear center on the seconds hand (5).

f. Mounting Timer S5 to Front Panel.

(1) Mount the 1/100 timer (S5) to the front panel with the four No. 6–32 by $\frac{3}{8}$-inch long mounting screws as shown in figure 16.

(2) Reconnect the tagged leads to the lower seven terminals of TB3 and to terminals 8 and 9 of TB4 (fig. 20).

50. Checking and Adjusting Timer S5 (fig. 19)

a. Clutch Shoe Alinement and Clearance. The clutch shoes in this timer are the U-shaped parts welded to the upper ends of parts (47, 51, 92, and 96) in figure 19. The clutch shoes must center on the face of the control disk assembly (34) as described similarly for the three-hand timer in paragraph 47*a*. If it is necessary to readjust the points, bend the armatures (92 and 96) slightly and adjust by eye.

b. Drive Spring Tension. The drive friction spring (33) tension should be set for the proper tension similarly to that described for the three-hand timer in paragraph 47*b*. The applicable control magnet assemblies are parts (52 and 99) in figure 19.

c. Seconds Reset Spring Tension. The seconds reset friction spring (35) should be set for the proper tension similarly to that described for the three-hand timer in paragraph 47*c*. The applicable control magnet assemblies are parts (52) and (99) in figure 19.

d. Jump Test. Energize the control magnet assemblies (52 and 99) ; then de-energize them. When the magnet is de-energized, the hand should stop rotating. If the hand continues to rotate, recheck the adjustments in *a* through *c* above.

e. Debuzzing Control Magnets. Check the control magnet assemblies (52 and 99) for buzzing similarly to the procedure described for the three-hand timer in paragraph 47*f*. The applicable armature adjusting screws are parts (45 and 98) in figure 19.

f. Calibration. Check the calibration of the timer similarly to that described for the three-hand timer in paragraph 47*g*. The applicable synchronous motor is part (59) in figure 19.

g. Contact Points. Check the proper operation of the contact block assemblies (14 and 18) as follows:

(1) Connect a light (with source voltage) in series across terminals 5 and 7 of terminal board TB3 (fig. 20).

(2) Move the hands manually, and visually check the operation of the contacts as shown by the light.

(3) The light should light seven $\frac{1}{100}$ minutes before the 50 mark and should go off at the 50 mark; and, it should go on again seven $\frac{1}{100}$ minutes before the 100 mark and go off at the 100 mark.

(4) If this time interval is incorrect, replace either (or both) contact block assembly (14 or 18, fig. 18), as necessary.

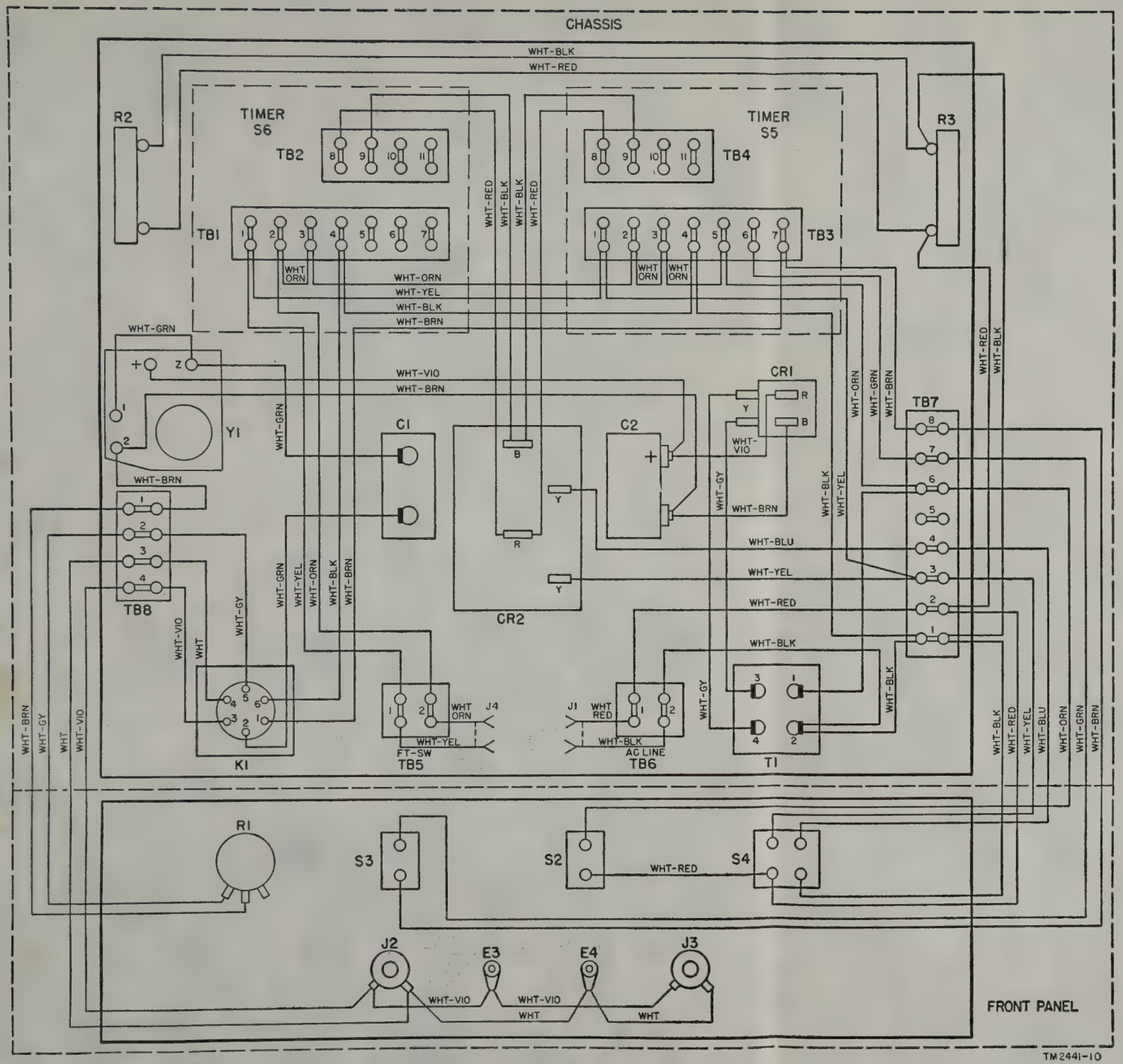
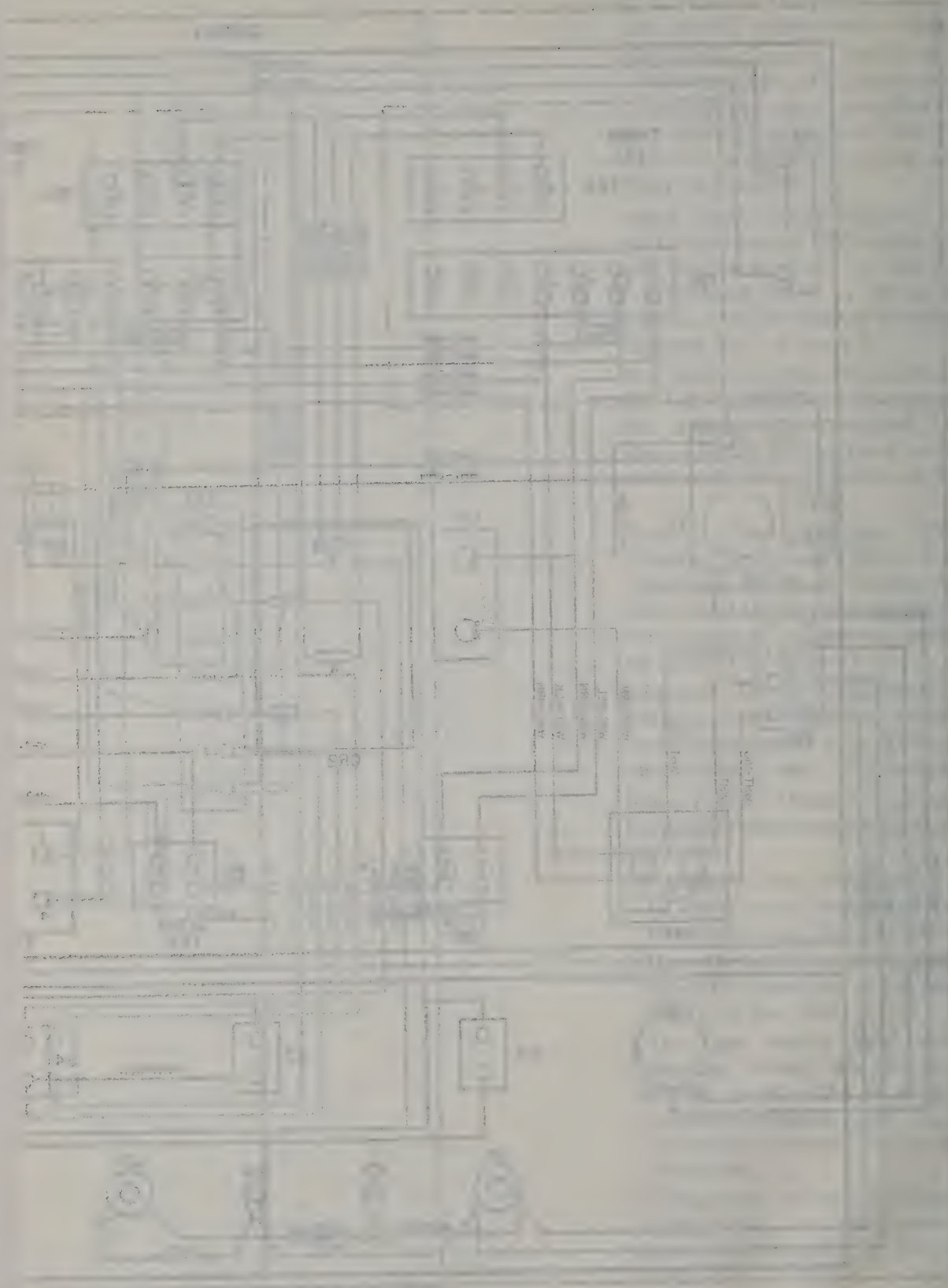


Figure 20. Time Signal Set ML–390/U, wiring diagram.



51. Refinishing

Instructions for finishing badly marred panels or the exterior of the carrying case are given in TM 9–2851, Painting Instructions for Field Use. These instructions should be followed when refinishing the signal set.

Section III. FINAL TESTING

52. General

This section is to be used as a guide in determining the quality of a repaired set. The minimum test requirements outlined in paragraph 54 may be performed by maintenance personnel with adequate test equipment and the necessary skills.

53. Test Equipment Required for Final Testing

No test equipment other than that specified in paragraph 38 is required for final testing of the ML–390/U. The ML–390/U is checked by observing its operation and checking its accuracy against a standard clock.

54. Tests

Check the operation of the ML–390/U as follows:

a. Connections. Connect the equipment for normal operation as described in paragraph 14.

b. Foot Switch Assembly Operational Check. Check the operation of the foot switch assembly as described in paragraph 17*b*.

c. Calibration. Check each timer for accuracy against a standard clock as described in paragraph 47*g*.

d. RESET Switch Operational Check. Check the operation of the reset circuit as described in paragraph 17*c*. If defective, check the applicable timer as described in paragraph 47 or 50.

e. Timing Signal, 1,000-cycle (fig. 4). Check the operation of the timing signal circuit as follows:

(1) Move CLOCKS ON–OFF switch S2 to the ON position.

(2) Move 30-SEC—60-SEC switch S3 to the 60-SEC position.

(3) Determine that a 1,000-cycle tone of approximately 7 seconds duration is heard in each of the PHONES jacks and across the binding posts at 60-second intervals. The signal should cut in and out abruptly and should be constant in volume and frequency through its duration.

(4) Note that the tone signal ends just when the black hand of $\frac{1}{100}$ timer S5 reaches 100.

(5) Move 30-SEC—60-SEC switch S3 to the 30 SEC position.

(6) Note that the tone now occurs every 30 seconds and ends with the $\frac{1}{100}$ timer black hands at 50 and 100.

(7) Adjust the signal level by varying VOLUME control R1. The signal level should increase when the VOLUME control is rotated clockwise and decrease when rotated counterclockwise.

(8) If the operation is not correct, recheck the mechanical assembly as instructed in paragraph 50*g*.

CHAPTER 7

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

55. Disassembly

Disconnect the power cable at both ends. Disconnect the foot switch assembly cable from the equipment.

56. Repacking for Shipment or Limited Storage

The exact procedure in repacking for shipment or limited storage depends on the materials available and the conditions under which the equipment is to be shipped or stored. If the original packing material is not available, the following chart is a guide to the amount and type of material necessary for adequate packing of the equipment. Refer to figure 2.

a. Material Required.

Material	Amount
Waterproof barrier	12 sq ft
Pressure-sensitive tape	10 ft
Single-faced, flexible corrugated paper	11 sq ft
Moisture-vaporproof barrier material	12 sq ft
Gummed paper tape	5 ft
Flat steel strapping	10 ft
Wooden shipping box	1 ea
Corrugated fiberboard carbon	2 ea
Desiccant	

b. Wooden Box Size. The dimensions for the wooden box for the ML–390/U are approximately 9½ inches high, 15½ inches wide, and 23 inches deep. The volume is approximately 2 cubic feet and the weight approximately 67 pounds.

c. Repackaging. Repack the equipment as follows:

(1) Wrap the foot switch assembly and the power cable in suitable cushioning material secured with appropriate tapes.

(2) Stow the packages that contain the foot switch assembly and the power cable in the right-hand compartment provided for this purpose in the ML–390/U carrying case.

(3) Fill all voids in this compartment with flexible corrugated paper pads. Insert the proper amount of desiccant.

(4) Mask the control panel with a ½-inch thick padding and secure with suitable tape.

(5) Place the cover on the carrying case and secure the four spring catches.

(6) Cushion the ML–390/U on all surfaces to absorb the shock of impact normally encountered in transportation.

(7) Place the cushioned ML–390/U in a corrugated fiberboard box.

(8) Seal the boxed ML–390/U in a moisture-vaporproof barrier.

(9) Place the moisture-vaporproof sealed ML–390/U within a close-fitting fiberboard box. The equipment is now ready for domestic shipment.

(10) For oversea shipment, place the domestically packed ML–390/U ((9) above) within a wooden box that has been lined with a waterproof barrier. See that the package fits snugly within the wooden box. Nail on the lid and further secure the wooden box with steel straps.

57. Destruction of Components

Follow some or all of the demolition procedures outlined in paragraph 58 to prevent the enemy from using the equipment. Demolition of the equipment will be accomplished only upon the order of the commanding officer.

58. Methods of Destruction

a. Smash. Smash the timers, buzzers, and rectifiers; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. Cut. Cut all wiring; use axes, handaxes, and machetes.

c. Burn. Burn the schematic diagram and case cover; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Explode. If explosives are necessary, use firearms, grenades, or TNT.

e. Dispose. Bury or scatter the destroyed parts in slit trenches, foxholes, other holes, or throw them into the streams.

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By Order of *Wilber M. Brucker*, Secretary of the Army:

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USAR: None.

For explanation of abbreviations used, see SR 320–50–1.

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